SMART CITIES; ANALYZING THEMES AND CONCEPTS OF SMARTNESS IN URBAN ENVIRONMENTS

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By
Ali Yousefimehr
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We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

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M.S. in Architecture

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Cities are grappled with a plethora of socio-political and environmental problems that necessitate the new type of solution models and strategies; such as, environmental pollution, scarcity of resources, cyber-attacks, and traffic congestion. These challenges, alongside constant population growth and densification in urban areas, have fostered cities to embrace and seek smart solutions which forced them to develop responsive and intelligent approaches to create economically viable, socially livable and environmentally sustainable cities. In the same vein, the smart city notion has gained particular traction in urban design and planning contexts. Yet, the definition and application of smart cities varied among academicians, practitioners, and urban planners. Smart cities are mainly characterized by the pervasive application of information and communication technologies (ICTs) in city functions, to deliver and provide efficient, safe, and reliable urban services to citizens. Following the ever-increasing focus in smartness in city planning, this research aims to review, explore, and analyze the smart city concept within the literature, followed by the complementary analysis of the pertinent smart city cases and smart city initiatives. Through identifying dominant domains in smart city platform, this study reveals the previous and current efforts of smart initiatives within the scope of smart urban practices, and provide a set of comparable implications for future researchers, architects and urban planners in the field.

Keywords; smart cities, sustainable urban development, smart initiatives, information and communication technology (ICT)

ÖZET

AKILLI ŞEHİRLER; KENTSEL ÇEVREDE AKILLILIK TEMALARININ VE KAVRAMLARININ ANALİZİ

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Şehirler, yeni çözüm modelleri ve stratejileri gerektiren bir sürü sosyo-politik ve çevresel sorunla boğuşmaktadır; çevre kirliliği, kaynak kıtlığı, siber saldırılar, ve trafik sıkışıklığı gibi. Kentsel alanlarda yaşanan sürekli nüfus artışı ve yoğunlaşmaşının yanı sıra, bu zorluklar, şehirleri ekonomik olarak uygulanabilir, sosyal olarak yaşanabilir ve çevresel açıdan sürdürülebilir şehirler oluşturmak için duyarlı ve akıllı yaklaşımlar geliştirmeye zorlamış, akıllı çözümler aramaları ve onları benimsemeleri için teşvik etmiştir. Aynı şekilde, akıllı şehir kavramı, kentsel tasarım ve planlama bağlamlarında özel bir ilgi kazanmıştır. Ancak, akıllı şehirlerin tanımı ve uygulaması, akademisyenler, uygulayıcılar ve şehir planlamacıları arasında değişmektedir. Akıllı şehirler, genellikle, şehre ve şehrin sakinlerine verimli, güvenli ve sağlıklı kentsel hizmetler sunmak için yaygın olarak uygulanan bilgi ve iletişim teknolojileri (BİT) ile karakterize edilir. Bu araştırma, şehir planlamasında sürekli artan "akıllılık" konusundaki odağı takip etmeyi, literatürdeki akıllı şehir konseptini incelemeyi, araştırmayı ve analiz etmeyi hedeflemekte, ve ardından akıllı şehir vakalarını ve akıllı şehir girişimleri üzerine tamamlayıcı bir çözümleme yapmayı amaçlamaktadır. Akıllı şehir platformunda baskın temaların belirlenmesiyle, bu çalışma, akıllı girişimlerin önceki ve şimdiki çabalarını akıllılık kapsamında ortaya koymakta, ve gelecek araştırmacılar, mimarlar ve kentsel planlamacılar için bu alanda bir dizi karşılaştırılabilir sonuç sunmaktadır.

Anahtar kelimeler; akıllı şehirler, sürdürülebilir kentsel gelişim, akıllı girişimler, bilgi ve iletişim teknolojisi (BİT)

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LIST OF ABBREVIATIONS AND TERMS

ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technology
RFID	Radio Frequency Identification
IES	Intelligent Energy System
GPS	Global Positioning System
EVs	Electric Vehicles
ROI	Return on Investment
GIS	Geographic Information Systems
AI	Artificial Intelligence
API	Application Programming Interface
CC	Cloud Computing
SUD	Sustainable Urban Development

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CHAPTER ONE

1 INTRODUCTION

1.1 Background

According to United Nations Report more than 50% percent of global population is now urbanized and it is expected that by 2050 the population will increase by 30% (i.e., from 7.2 to 9.8 billion inhabitants) (Moreno, Clos, Ki-moon, & United Nations Human Settlements Programme., 2016). The complexity of socio-ecological and political urban systems on the one hand and the consequence of the constant growth on the other have created an unbalanced rate of urbanization, economic turmoil, and several dysfunctional urban infrastructures (UNCTAD, 2016). These factors, alongside other issues related to health, traffic, and scarcity of resources, hamper the growth of cities (Kitchin, 2014a). This has triggered the systematic and pervasive use of technology as the primary solution for those issues (Joshi, Saxena, & Godbole, 2016). Hence, the concept of smart cities has developed. With the aid of technological services in a broad aspect, smart cities ensure the sustainable environment in which public services are reliable and efficient (Albino, Berardi, & Dangelico, 2015).

A smart city is a city that implements intelligent systems and information functions in the core of urban infrastructures to provide more comprehensive and inclusive city services

and to improve the quality of urban living for their residents. The key message is how to efficiently, and continuously cities can come up with smart and agile solutions to enhance workability, resilience, and sustainability. Implementing smart city concepts will help to solve some of the problems that growing cities face.

1.2 Problem Statement

There is a fast-pace attempt among cities to become smart and intelligent. Urban designers embrace smart planning as a critical element for sustainable development (Angelidou, Psaltoglou, Komninos, & Kakderi, 2018), the infrastructural design includes smart grids for energy optimization and intelligent systems for information and communication technologies (ICT)[1]. (Hollands, 2015; Rivera, Eriksson, & Wangel, 2015). The general focus is the implementation of information technology and data models in urban management, ensuring the fast delivery of services (Dainow, 2017), and resulting in more productivity (Rodríguez-Bolívar, 2015). However, the definition, the scope, and the application of the smart city remain inconclusive as several scholars have already pointed out some concerns. It is worth investigating whether these concerns solely refer to infrastructure and development of utilities (Lin & Geertman, 2015), or processes in urban design and planning, or urban policy and governance.

Alternatively, does smartness requires cities to solely invest in the advancement of ICTs and their relevant technological infrastructures? (Caragliu & Del Bo, 2016) Will smart projects be in the risk of investing in intelligent solutions without issuing the underlying social and cultural values embedded in city functions? (Kitchin, 2016) Does the notion of smartness contribute to social inclusivity in urban places? And how these urban space creations could be manifested through the interplay of architectural design and city planning objectives? Considering the multi-directional trends in the architectural profession, urban design, and city planning, providing clear answers to these mentioned concerns will be inadequate and inconclusive. However, some are discussed within the limited scope in this research.

[1] ICT can be broadly defined as a technological model to analyze, store, and process information and data in electronic means that used in extensive communication functions with the integration of the human element. Source; http://journals.iupui.edu/index.php/advancesinsocialwork/article/view/241

1.3 Objectives

This thesis aims to provide a meaningful and comparable explanation of smart cities and smart/resilient planning with the main attributes of smart practice in the domain of urban design and planning and also to identify potential merits and opportunities for implementation of smart services and technologies both in city design strategies and architectural practices. Through the finding and analysis of pertinent case studies, smart enterprises/initiatives[2], in particular, the research aims to provide an applicable framework for scholars and practitioners working in multiple city contexts, to implement and apply various theories and guides acquiring from the research in the initiation of smart activities and projects.

1.4 Methodology and Outline

This study starts with the literature review in the Second Chapter about the concepts and the implications of smart planning, and smart city domains, following the categorization of the central themes and attributions for being smart. Also, outliners for current issues and sub-branches of smart city cases (within smart initiatives) will be explored. Pertinent outcomes will be presented in the subsequent chapters. This study relied on primary data sources such as books and noted research articles in the area of smart cities, several related case projects, municipality reports and papers as secondary data sources. Here some of the secondary data-sources are non-academic (generic issues, catalogs, etc), and they may provide different values and outcomes on the smart projects in cities. That is, some articles and initiative/firms reports may not include a systematic data-collection process.

In order to address research objectives and give practical implications for the research, in Chapter 3, three smart city paradigms – Singapore, Amsterdam, and Stockholm were introduced as case studies for the primary analysis. Considering the variety of smart projects/initiatives, these selected cities could provide a proper grasp of smart city experimentation within (and beyond) the context of urban design.

[2] One definition of smart initiatives can be referred to multi-stakeholder (profit/non-profit based) partnership with municipalities and urban agents to address civic issues and offer services with the aid of technology support; ICT, big data analytics, cloud-based services, IoT, etc.

Chapter 4 provides an analysis of the values, themes, and applications for integration of smart applications within smart initiatives according to the data gathered through articles, published case reports, and official city reports about smart city efforts.

Chapter 5 presents general findings and potential attributions concerning the implementation of smart city efforts and mainstreaming the smart initiatives to reach an acceptable level smartness based on the current discussion in the field. The provided framework can serve as a supplementary guide for architects, urban designers, policymakers, and city planners.

Implementing smart city concepts and valued attributions will open up multi-faceted windows toward reaching resilience cities that concurrently seek for delivery of valued services to their citizens and promote the healthy and livable built environment.

CHAPTER TWO

2 THEORETICAL BACKGROUND

2.1 Literature Review

Cities are confronted with a plethora of complex issues; population growth, scarcity in resources, traffic congestions, climate change and hazards, etc. (Kumar & Prakash, 2016; Leichenko, 2011). These challenges hinder cities from reaching their objectives in terms of socio-economic progress and prosperous life for their citizens. The urgency to address these issues has fostered cities to seek a variety of development paradigms such as smart growth and smart urbanism to deal with these problems (Ssekatawa, 2016). Based on the normative discourse, Luque-Ayala & Marvin (2015), define smart urbanism[3] as: "a futuristic solution brought to the present to deal with a broad array of urban maladies, not limited to congestion, transport, resource limitation, climate change and even the need to fathom democratic access.. taken together, these new drivers and programs are creating a new lexicon through which the development of (smart) cities is being forged like urban

[3] To be more precise, 'Smart Urbanism' is a movement that embraces an evolution in design and planning of cities. Lying on urban theories, systems thinking and new urban science, it is developed to deal with the complexity of the city. Smart Urbanism presents how *"cross-over thinking can translate into the choice architecture of practical solutions"*, and acknowledge relevant approach in *"planning, ethics, precedent, learning and adaptation mechanisms, protocols, and cultural tests"* for success of cities. Source: Rodulfo, R. (2014). Glossary of Smart Cities and Urban Computing Terms. Retrieved from http://www.raimundorodulfo.com/resume/files/GlosaryOfSmartCitiesAndUrbanComputing.pdf

apps, big data, intelligent infrastructure, city sensors, urban dashboards, smart meters, smart buildings, and smart grids." (p. 2107)

The term of a "smart city" is not one unified notion or one application of specific technology in the city domain (Caragliu, Bo, & Nijkamp, 2010; Cohen, 2013; Hollands, 2015); Several scholars provided a variety of interpretations and clarifications around the topic. Lombardi et al. (2012) described smart cities as "the application of information and communications technology (ICT) with on the role of human capital and education, social and relational capital, and environmental issues are often indicated by the notion of smart city." (as cited in Albino et al., 2015). The authors elaborated on creating integrative models that combine intelligent services with the environmental and organizational assets of the cities. (Albino et al., 2015).

The notion of smart cities today is being promoted by local governments, city administrations, technology firms, and corporate actors (Albino et al., 2015; Hollands, 2015; Kitchin, 2016). Through the integration of interactive and networked infrastructure, these actors aim to renovate and rebuild cities. This is demonstrated by the rapid growth of smart initiatives in developed countries and the prevalence of utility and telecommunication firms such as IBM, Google, Cisco, Microsoft, etc. (Washburn & Sindhu, 2010). For instance, the '*Centro De Operacoes Prefeitura Do Rio*' in Rio de Janeiro, Brazil (Kitchin, 2014b) is an instrumented system built by a city government in partnership with IBM (Ssekatawa, 2016) to facilitate, manage, and monitor several aspects of the city services (Kitchin, 2013, 2014b).

Figure 2-1 City Operation Center, Rio De Janeiro, the center has been created to promote the qualities and urban policies through the use of technology in various fields of traffic control, environmental monitoring, and security services, https://www.betterworldsolutions.eu/smart-city-projects-rio/

These endeavors and movements are aimed at creating a pathway through which the development of smart cities have been shaped. These include but not limited to ICTs, big data[4], internet of things (IoT[5]), city sensors[6], intelligent systems, and geo-visualization tools (Angelidou, 2014; Kitchin, 2014a; Kumar & Prakash, 2016). As Hollands (2015) states, governments and city agencies need to realize the "socio-economic progress which embedded in the core aims of smartness" (Hollands, 2015). In this regard, smartness has been recognized as an effective response to various aspects of contemporary urban questions (Angelidou, 2016; Kitchin, 2014a).

[4] The 'Big Data' is huge amounts of data that can be processed by industry/business to make proper decisions, the analysis of big data mainly dealt with large volumes of information to uncover patterns and insights about particular event. Source: https://dzone.com/articles/how-big-data-has-the-biggest-impact-in-smart-citie

[5] Internet of Things (IoT), *"is a computing concept that describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices. The term is closely identified with RFID as the method of communication".* Source: https://www.techopedia.com/definition/28247/internet-of-things-iot

[6] Sensor or meter as an electronic component, device or module to detect events, triggers, and disruptions in the surrounding environment. Source: https://www.telensa.com/news/smart-cities-a-glossary-of-terms

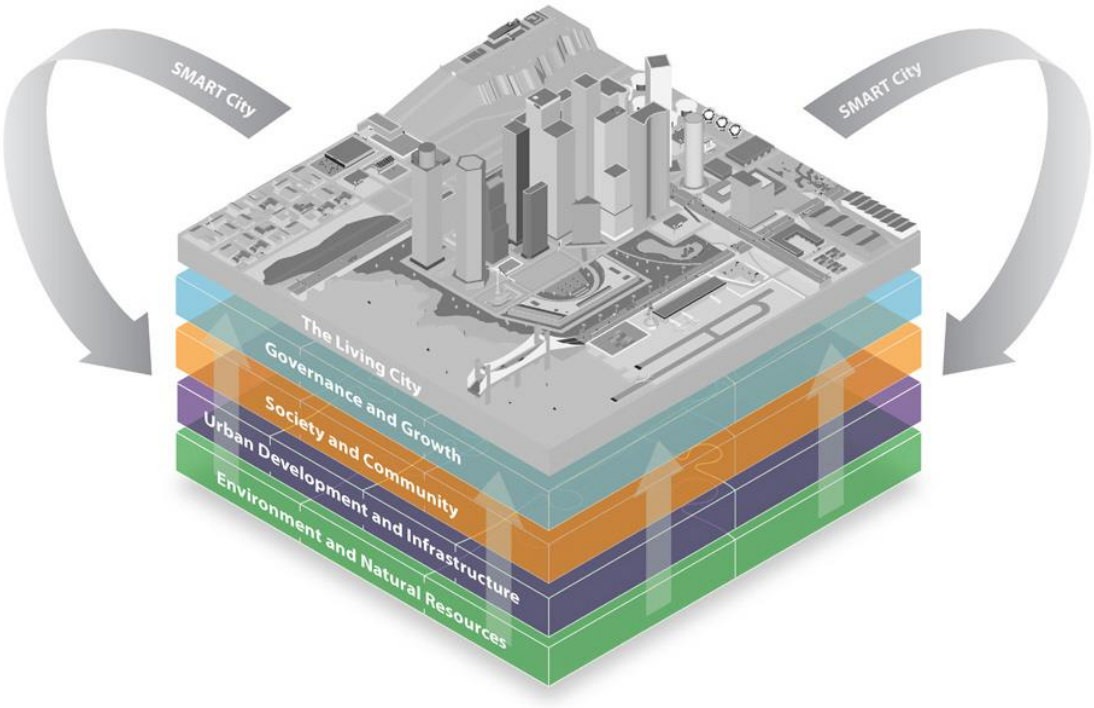

Figure 2-2 Conceptual representation of a smart city with its core layers, https://www.designingbuildings.co.uk/wiki/Designing_smart_cities

2.2 Pertinent Domains in Smart City Practice

Firstly, there is a consensus on the role of ICT for the characterization of smart city (Angelidou, 2016; Diego Giron, 2018) and secondly, the effective use of such technologies to promote and improve the efficiency, activity, and services of city processes. The key thing is to remember that each city has its characteristics and values. That being said, the smart city attributions are fluid respective to size, location, socio-political manifestations of the cities. As mentioned earlier, various ideas have been developed and discussed concerning smart cities, as such; key domains of focus can be referred to information technology, services, and applications (organizational/governmental contexts) that adequately pertain to smart efforts.

2.2.1 Information and Technology-Oriented Approach

Intelligent systems are composed of several interconnected modules/units that enable optimum efficiency in service delivery and automation (Ferraro, 2013). Harrison et al. (2010) refer to “smart city” as a city which “instrumented, connected, and is intelligent”

(as cited in Albino et al., 2015). He clarifies that smart systems have the capacity of capturing and integrating data through meters, appliances, sensors, and devices in which the data can be combined and analyzed to be used in computing platforms and communication networks (Albino et al., 2015). Thereby, data and information can be visualized and modeled for particular urban services. Examples of these are smart homes equipped with mobile sensors and embedded devices (Ibid).

The pervasive growth in data is due to several different technologies and networked infrastructures (Brandtzaeg & Følstad, 2017) and their rapid embedding into everyday life and civic spaces (Kitchin, 2014b) (such as home broadband services, ADSL, cables, and fiber-optic systems). Thanks to the fast-spreading of IT devices, the technology became part of our outer world and daily life, which opened a whole new platform for services and products: like "the internet of things" and "information intelligence". The idea of smart infrastructures is based on such internet-cloud based devices that connect all possible technologies in one central module, accessible and manageable from all over the world (International Telecom Union (ITU), 2015).

Due to the essential dependence of smart cities on the use of infrastructures, ICTs in particular, a few notes are provided to identify the goals and aims of the technology actors within this context. Information Technology (IT) acts as a base and principal element in partnering cities (Rivera, Eriksson, & Wangel, 2015), in particular, active technology firms such as Cisco[7], and IBM[8] have been participated in multitude of technology projects to support cities in the adoption of ICTs and emerging trends like intelligent thinking and smart/resilient planning (Hollands, 2015). The effort of some these corporations with their specified roles outlined in the following.

[7] Cisco Systems Inc. is the American technology company and worldwide leader in networking. The company was founded in 1984, and since then it has provided network foundations for service suppliers, enterprises, government agencies, small and medium businesses, and educational institutions, source : https://www.cisco.com/c/en_au/about/who-is-head.html

[8] International Business Machine (IBM), one of the pioneers in information technology, providing an extensive hardware, software, and network solutions. It is founded in 1911 and nicknamed as 'Big Blue'. Over the years the company shifted its focus from hardware-software to services and network delivery. It has been modified to cloud-based services and data-driven solutions. Source: https://searchitchannel.techtarget.com/definition/IBM-International-Business-Machines

Table 2-1 Example of major technology firms and suppliers in the realm of smart cities
(for thorough explanation check ("Delivering a solution to our future – Expo Magazine™," n.d.)

Role of Technology Suppliers/Providers	**Example of Major Actors (the list is not exhaustive)**
Integrators (project integrators in smart city development, providing unified and end-to-end integration of multiple sectors_ and through pre-packaged platforms)	IBM, https://www.ibm.com/tr-tr/ Accentuate, https://www.accenture.com/tr-en Oracle, https://www.oracle.com/index.html
Network Service Providers (Providing collaborative networks, enterprise, and data analytics working solutions- Hard and Soft assets (e.g. smart meters, distribution devices)	Huawei, https://www.huawei.com/en/ Ericsson, https://www.ericsson.com/en Siemens, https://new.siemens.com/global/en.html Cisco, https://www.cisco.com/
Operative Service Providers (Offering complete management, round the clock monitoring, compliance, and on-site consulting)	Google, (!) Microsoft, https://www.microsoft.com/en-us Serco, https://www.serco.com/ General Electric, https://www.ge.com/ Toshiba, http://www.toshiba.com/tai/

While the smart city development objectives differ globally resulting in new forms of collaboration between governments, institutions, and technology corporations, 'the information and communications technologies (ICTs)' lie at the core of this concept, where a smart city can be made of two domains; soft and hard domains (Angelidou, 2014). The hard category has more focus on sensors and wireless technologies used to cope with big data[9] (Kumar & Prakash, 2016), and in the soft one there is a limited role of ICT, and more attention is on the involvement and participation of citizens (Angelidou, 2014). Hence, smart city initiatives can both be valued by the distribution of sensors and wireless technologies and by practices that focus on creating social and cultural values (See

[9] Data within the realm of a smart city is seen as being neutral. Big data in urbanism is inherently is a valuable source of ideas, seeking to make the living space safe, reliable, and productive. However, the data is far more complicated than its pure existence (Kitchin, 2014b). That is, the data is dependent on ideas, technologies, and contexts that produce, process, analyze, and store theme (Kitchin, 2014b). What kind of data is generated is the product of choices and constraint that shaped by a system of ethical consideration and political opinion, or resourcing (Kitchin, 2014b). Unquestionably, big data is systems to produce data which is useful for managing city assets, but the politics and limitations of such data and the methods to produce and analyze them need to be examined as an underlying focus of smart projects. (The argument adopted from (Bücker, 2016) *and* (Kitchin, 2014b)

Appendix Part 2_A and B). Furthermore, the concept often interlaced with other city terms that all focus on the adoption of ICT in cities, for instance: intelligent city, the knowledge city, the resilient[10] and digital capital, of which the smartness has gained dominance in the literature (Albino et al., 2015; Hayat, 2016; Nam & Pardo, 2011).

Figure 2-3 Word Cloud representation of key terms used in the literature for this specific research, Source by Author, (created via Wordle)

2.2.2 Service-Oriented Approach

The smart definition is no longer limited to the use of technology and creative services; it also includes people and urban communities as critical actors of smartness (Albino et al., 2015). People are the key drivers of smart growth; creating a social infrastructure is an essential basis that "connect people and create relationships" (Alawadhi et al., 2012), acting as a magnet to mobilize the community and citizens' efforts. As Nam and Pardo (2011) specify: "the smart concept linked to the sense of community" where civic groups and citizens work in tandem to city governments to "encourage diversity, social networks and

[10] The resilient development paradigm within the scopes of 'urban resilience' and 'resilient development' has been used in several fields, namely ecology & environmental conservation, disaster risk reduction, and urban planning. A generic definition by UNSDR states that "a resilient city is characterized by its capacity to withstand or absorb the impact of a hazard through resistance or adaptation, which enable it to maintain certain basic functions and structures during a crisis, and bounce back or recover from an event.." ("Resilient City | Planning Tank®," n.d.). The resilient city elevates the capacity of urban systems and infrastructures to favorably "respond to heterogeneous pressure factors" (climatic, ecological, environmental, and governmental) and pertains to address holistic values of SDGs.There is an on-going discussion around the capacity planning and relation of smart city with a resilient focus in natural and built environments. A few noted reviews can be found in (Papa, Galderisi, M.C., & Saretta, 2015), (Growth, 2018), and (Babelon, 2016).

cross-sector innovation" (Nam & Pardo, 2011). Thus, smart initiatives should clarify their goals and aims in response to the needs and values of society (Ssekatawa, 2016).

In the same manner, Rivera et al. (2015) emphasized that the emergence and enrollment of ICT for reaching sustainability in urban areas will be prerequisite for environmental benefits (Rivera et al., 2015). In this regard, Ssekatawa (2016) states that smartness seeks citizens to understand the intelligent urban agenda that:

"A Smart City has embedded *smartness* into its core operations and is guided by the overarching values of becoming sustainable and resilient to its core. It monitors, analyzes, and optimizes its urban systems, both physical and social, through transparent and inclusive information feedback mechanisms/procedures. It commits to continuous learning and adaptation and aspires to improve its inclusivity, cohesion, responsiveness, governance and the performance of its social, economic and physical systems." (I.C.L.E, 2016; Ssekatawa, 2016)

This domain includes main factors of smartness, which encompasses several attributions of our society, environment, government, etc. Several authors provide pertinent values about performance, effectiveness, and public services. Given the scope of this research, the following sub-domains acquired from the review (See Table 2-2). As Soderstrom et al. (2014) state, technology driven-urban utopia leads the false conception of a smart city that only cater to corporations and business groups without considering social and cultural inputs. He further adds that "In this vision, cities are conceived as systems of systems characterized by inefficiencies and urban pathologies that need to be cured using a massive input of technology, mainly provided by ICT companies". (as cited in Komninos & Mora, 2018).

In the same venue, other scholars like (Caragliu & Del Bo, 2016; Hollands, 2015; Kitchin, 2015) elaborated on the holistic consideration of smart city development in which the smart planning is the inclusive focus of infrastructural, socio-cultural, and political factors pertain to human and social values. These interpretations align with Holland statement that "the smart city must seriously start with people and the human capital side of the equation, rather than blindly believing that IT itself can automatically transform and improve cities." (as cited in Komninos & Mora, 2018).

The shifting nature of the smart city within the practitioners' point of view have embodied in the ICT-framed services and smart devices designed and optimized by IT specialists and engineers. However, what is the role of architects and urban designers in shaping the spatial constructs of public spaces and how they can create opportunities to address the promise of the equitable, yet smart environment? Similarly, Rem Koolhaas, honored dutch architect stated that: "We are fed cute icons of urban life, integrated with harmless devices, cohering into pleasant diagrams in which citizens and business are surrounded by more and more circles of service that create bubbles of control. Why do smart cities offer only improvement? Where is the possibility of design and control?" ("A Who's Who of Smart Cities | Architect Magazine," 2019). This is referred to as stimulating discussion specifically in the realm of urban spaces (Hill, 2015). A debate around the space making across the domain of smartness fall into the smart performative design with the implications on interactive public areas and augmented/virtual reality ecosystems that can provide informational and tangible experiences embodied in diverse forms of smart applications.

These architectural and design values can be shaped and customized to increase their sphere of influence to create more equitable and engaging urban districts (such as sensible city labs or virtual city topologies). Leon Van Schaik (2009) aptly articulate the value of spatial and smart intelligence "what if our forebears had professionalized architecture around spatial intelligence rather than the technologies of shelter? Might society find it easier to recognize what is unique about what our kind of thinking can offer?" (as cited in (Reinmuth, 2017). Although being neutral, this viewpoint tries to imply the other values of intelligent space creation which can equally be considered as a part of communicating streams such as intelligent parking lots, kinetic pavements, and possibly sensory modes of public and informational services through software and smart devices.

Similarly, Akgun (2015) expresses that "smart cities can communicate with its intended audience and transfer data and information. Sensors and digital technologies can transform our cities into computers that can run outdoors. We are not developing technology but people-oriented projects. With an increase in initiatives of smart cities, people living in those cities will be an agent of this change". She further adds that "in the current digital age, besides digital society, architectural process and the cities also went into profound

change that can be regarded as Communication technology and Informational Design" (Akgun, 2015). Creating shared (and IT dominant) spaces seem to be genuine attempt to reconfigure urban design elements pertain to the creating connected spaces whether from openly accessible platforms like hackathons and design workshops or 3D-enabled design environments and digital tools (Figure 2-4).

Figure 2-4 Data Drive, an interactive visualization tool for urban designers that allows to visualize and configure series of data set according to the inputs like transportation routes, parking locations, building energy consumption, etc. https://morphocode.com/v

In order to review the practices and efforts of smart initiatives specifically, it is necessary to elaborate on themes and subdomains of smartness. Following the comprehensive literature review on the term, four (dominant) values picked in the area of smart cities to provide a highlight on variability/scope of smart initiatives and smart projects. Any application/service domain in smart initiatives needs to consider the mentioned themes in their practice from the IT domain to infrastructural planning, and from environmental monitoring to mobility and governance.

The objective of this classification is to aptly understand the coverage and domain of special services within the city context. It is evident that smart practices need to take on a holistic and multidisciplinary perspective in implementing ideas and solutions. Understanding the underlying goals of technology firms and city practitioners seem to be an important factor in the formulation of smart projects.

Table 2-2 Summary of the key smart city characteristics with pertinent sub-sectors, compiled by Author

Themes	Description	Sub Dimensions	Relevant Authors
Smart Environment	Emphasizes the need for responsible resource management and sustainable urban planning. Through pollution and emission reductions, and efforts towards environmental protection, the natural beauty of the city can be enhanced. Smart cities promote the reduction of energy consumption and the integration of new technological innovations that result in efficiency gains.	Delivering secure energy and clean water supply; treating waste and water resources, offering safe transportation, the transition to green energy sources; providing secure telecommunication and data technology; Smart grid, energy transition, smart homes, traffic control	(Breuer et al., 2014; Chourabi et al., 2012; Kitchin, 2016; Nam & Pardo, 2011; Rivera et al., 2015; Shahrokni, Arman, Lazarevic, Nilsson, & Brandt, 2015; Somayya & Ramaswamy, 2016; Yin et al., 2015)
Smart People (Citizens)	Emphasizes on delivering a high and consistent level of education to the citizens, and also describes the quality of social interactions, cultural awareness, open-mindedness and the level of participation that citizens hold in their interactions with public life.	Providing high-quality public services, communicating platforms for, affordable healthcare services, efficient mobility, and transportation; Social cohesion, tourism, media and entertainment, education, public services; healthcare	(Caragliu & Del Bo, 2016; Commission, 2014; Ho, 2017; Madakam, Ramaswamy R., & Date, 2017; Nam & Pardo, 2011; Sing, Amarnath, & Parrish, 2014; Yin et al., 2015)

Themes	Description	Sub Dimensions	Relevant Authors
Smart Business (Economy)	refers to a city's overall competitiveness, based on its innovative approach to business, research, and development (R&D) expenditures, entrepreneurship opportunities, productivity and flexibility of the labor markets, and the economic role of the city in the national and international market.	Facilitating partnership platforms, imitating smart groups and start-ups, renovating business activities for the locals and civic communities, improving ICTs through e-commerce, smart finance, and consulting groups; efficient service delivery; supply chain, banking and finance, entrepreneurship, technology management	(Alawadhi et al., 2012; Caragliu & Del Bo, 2016; Eden Strategy Institute, 2018; Hollands, 2015; Kitchin, 2016; Rivera et al., 2015; Sing et al., 2014; Yin et al., 2015)
Smart Governance	Addresses participation at a municipal level. The governance system is transparent and allows for citizens to partake in decision-making. ICT infrastructure makes it easy for citizens to access information and data concerning the management of their city. By creating a more efficient and interconnected governance system, barriers related to communication and collaboration can be eliminated.	Offering governmental services through web-based platforms; monitoring public safety and proving surveillance for critical IT infrastructures; enabling citizens to access to data and documentation; Administration emergency and response, smart government, transport management, policy-making	(Alawadhi et al., 2012; BIS, 2013; Diego Giron, 2018; Hollands, 2015; Johnson, Hollander, & Whiteman, 2015; Regional Publications, 2014; Singh Kalsi & Kiran, 2013; Yin et al., 2015)

2.2.3 Application (Context)-Oriented Approach

Another critical part of smart efforts lies in the partnership and cooperative platforms among the stakeholders, which involve a multitude of e-processes where city departments engage with IT-businesses and research institutions as partners to establish a framework that promotes collaboration and knowledge transformation (Breuer et al., 2014; Ching &

Ferreira, 2015; DuPuis NStahl E, 2016; Luque-Ayala & Marvin, 2015). These urban ecosystems acknowledge collective intelligence and citizen engagement for providing innovative living experiences (Ferraro, 2013). Through supporting and creating room for social inclusion to foster the city's capacity for learning and adaptation.

Another discussion is on the governance and administration mechanisms and whether or not smart initiatives take top-down or bottom-up approaches. A few researchers like Hollands (2015), Kitchin (2014), and Mora (2017) elaborated in the different strategies that mark contemporary city planning "top-down, centralized, and corporate-driven", or "bottom-up, decentralized, and grass-roots community efforts" (Kitchin, 2014a; Komninos & Mora, 2018). Top-down Smart initiatives mainly originate from the political and administrative leadership with the city agencies, which dictate a specific plan (Komninos & Mora, 2018). This approach is mainly attributed by limited or even absent involvement of community groups (or citizens).

The dynamics of this method pertains to "closely related to the technologically deterministic idea of a control room for the city. It aims at providing an ICT-based architecture to overview urban activities as well as the tools to (automatically) interact with infrastructures and adjust parameters to predefined optima" (Breuer et al., 2014). This approach translates to cities that embedded and integrated ICTs and optimization infrastructures in their initial development goals/plans. The prime examples of this vision are Songdo and Masdar City, which applied smart functions from scratch (Breuer et al., 2014). While being futuristic and unconventional in essence, the mono-directional top-down vision is anonymous and unreferenced, leading to unattended economic efforts that "turning cities into digital marketplaces for large multinational firms, blurring the lines between public and private and concealing new forms of social and economic inequalities."(DuPuis NStahl E, 2016; McLean, Bulkeley, & Crang, 2015)

In contrast, bottom-up smart planning relies on the self-organization and community-driven strategies that foremost consider citizens as the functional actor of planning and local policymaking. The importance of citizen-engagement and the opportunity to become active partners in city making and re-making smart efforts could result in a meaningful contribution to the city projects. Lindsay (2011) appropriately commented on this vision:

“The bias lurking behind every large-scale smart city is a belief that bottom-up complexity can be bottled and put to use for top-down ends — that a central agency, with the right computer program, could one day manage and even dictate the complex needs of an actual city. The smartest cities are the ones that embrace openness, randomness and serendipity -- everything that makes a city great.” (as cited in Breuer et al., 2014)

Within this context, smart efforts can render on partnership ecosystems that encourage diversity, co-creation of ideas, and multi-disciplinary practices that ensure transparency and openness of targets and policies. In other words, “smart city strategies should represent the needs and capabilities of a variety of city stakeholders. In particular, relationships with community groups, the private sector and universities are core to developing well-rounded and sustainable initiatives” (BIS, 2013). It is worth mentioning that, creating a comprehensive platform in which stakeholders involved (whether city departments or community groups) seem to be an adept approach in the creation of smart initiatives which are driven by needs/demands of their citizens and not by the supply of technology firms alone.

With the rapid rate of urbanization and concurrent stress on natural resources, the promotion of smart values can offer tangible and short-term solutions to current urban issues. To ensure that cities are striving for economic prosperity, there should be evidence of smartness in every piece of city services in terms of resource efficiency, financial stability, sense of shared community, and capacity to withstand the future disruptions. Pursuing smart and resilient goals in the core of city planning can create multi-layered and connected streams of data and information that can cater to urban-innovation clusters and several city agencies to facilitate the service delivery for the citizens.

CHAPTER THREE

3 CASE STUDIES

3.1 Smart City Case Selection

In 2015, there were around 150 smart projects around the globe. There were composed of city-owned infrastructures or designed via community platforms (Albino et al., 2015). Among those smart initiatives, the United States had 30 projects, Europe 50, and Asia around 40. While the article may not elaborate on the specific city cases, considering the ever-growing ICT technology in developed countries, there seem to be a large number of active projects in European, East Asian countries, as well as North and Central America. Also, there are a couple of institutions and companies that carried out appraisals of completed/ongoing smart projects around the world, which can give introductory information on the field, namely "EU Smart Cities Information System", "Brussels Smart City", "Bright Cities", and "Smart Cities Council". Also, see Figure 3-1 for noted examples of smart cities/projects around the world. It should be noted that smart values/dimensions are fluid and changeable respective to the context and objectives of the specific city or district. Thus selecting a city that manifests a whole and comprehensive paradigm of smart thinking in design and planning could be an exemplary city model for other developing regions. A couple of valid points have been provided in the following sentences.

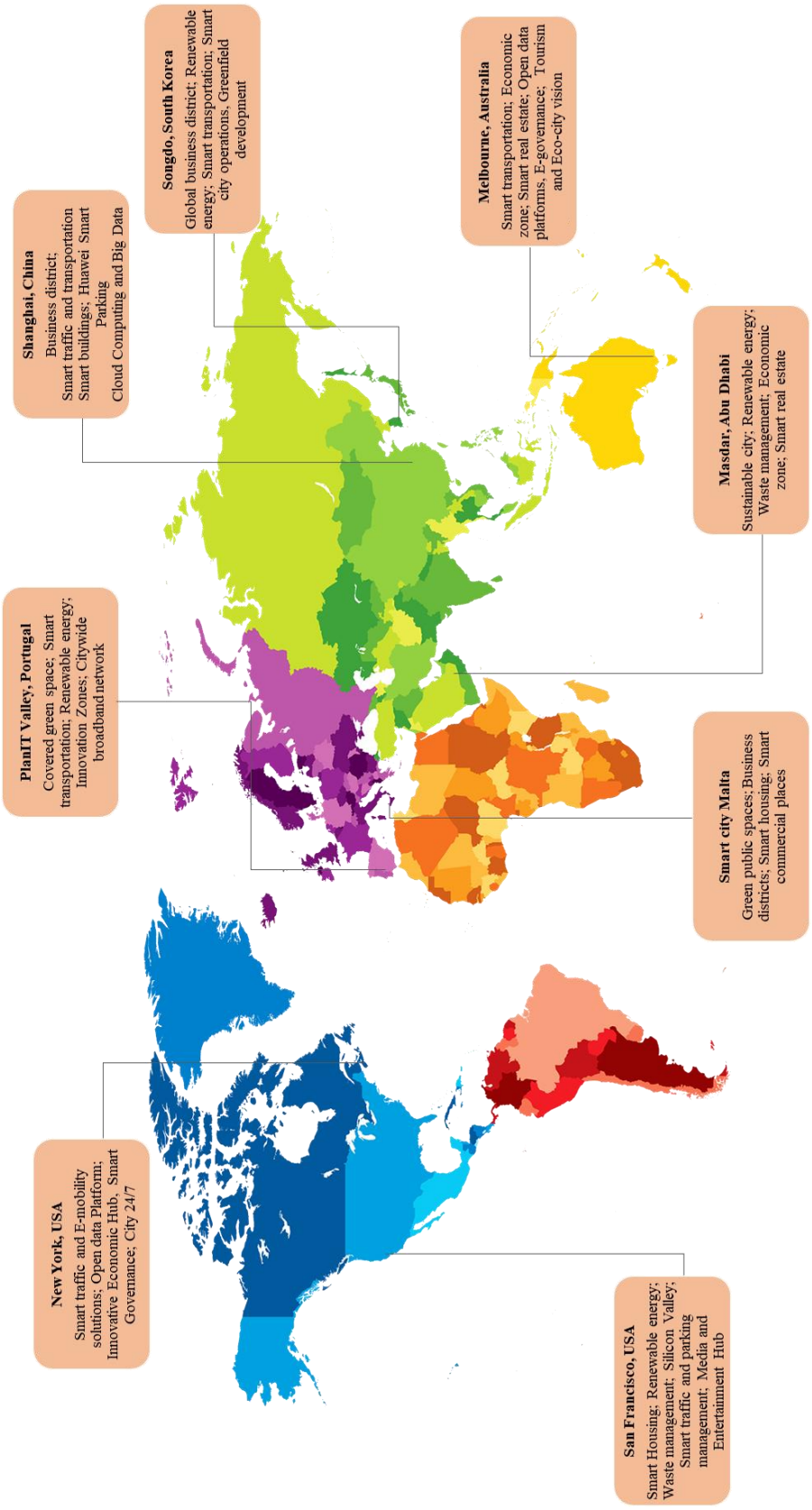

Figure 3-1. A few examples of smart cities with the key attributions of smartness for each case (provided by Author)

Given the particular scope of this research, the following cities were selected to address the mentioned objectives in the first chapter; Singapore (as the leading nation for the improvement and integration of smart Platforms and ICT infrastructures), Amsterdam and Stockholm (as dominant examples of smart community development practices and environmental friendly districts in Northern Europe). The selection criteria are based on existing and pervasive smart city applications in each city. The primary selection points are highlighted in the below diagram (Figure 3-2).

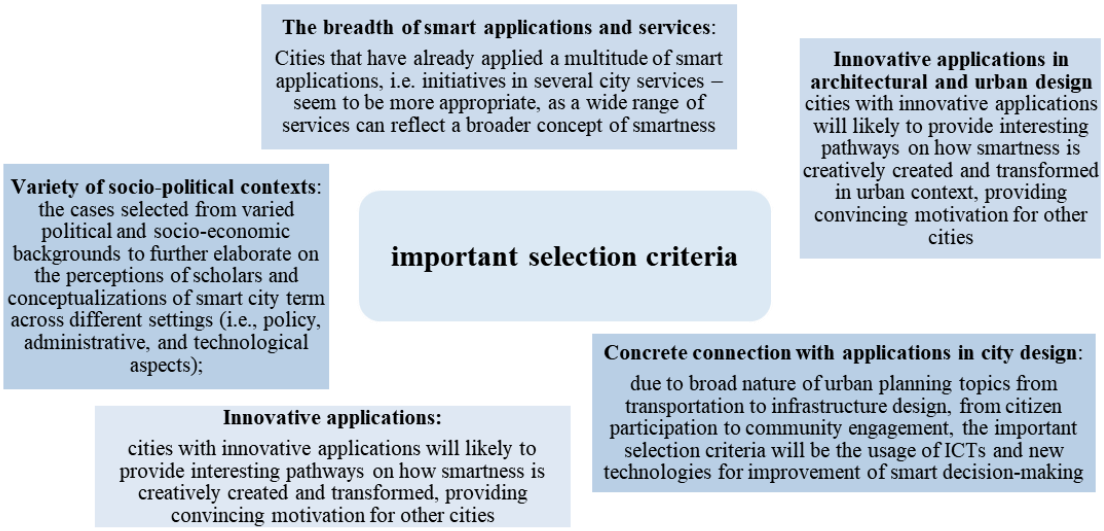

Figure 3-2 A few essential aspects concerning the selection of smart city cases, provided by the author, multiple sources: (Angelidou, 2016; Caragliu & Del Bo, 2016; Kitchin, 2016; Lev-on, 2013; Richter, Syrj, & Kraus, 2015)

As stated in the diagram, for the selection of case studies, there are a couple of relevant points in terms of choice. Due to broad nature of urban planning topics from transportation to infrastructure design, from citizen participation to community practices, the critical point is the integration of ICTs and intelligent systems in governance and policy-making (Manville et al., 2017). In terms of number and application, cities that have already implemented smart initiatives in several city services seem to provide more room for service delivery and innovation. Also, selecting cities from varied political and socio-economic backgrounds could further elaborate on the perceptions of scholars and conceptualizations of smart city efforts across different city domains (i.e., policy, administrative, and environmental settings); (Angelidou, 2016; Caragliu & Del Bo, 2016; Kitchin, 2016).

3.2 Singapore

In Singapore, the 'smart nation' represents transparent and deliberate action plans which seek to provide a livable and healthy environment for businesses, community startups, and local entrepreneurship. According to the Smart Nation Program Office, the potential aim is "to support better living, stronger communities, and create more opportunities, for all". (Centre for Liveable Cities Singapore, n.d.). Due to its unique geographic boundaries, smart nation plan stands out as a leading smart platform for South-eastern Asian countries. (Ho, 2017). According to iNation Officials: "It is Smart Nation's very distinctiveness from the smart city that gives Singapore an opening to develop its own capacity for planning urban operations for and with its citizens." (Centre for Liveable Cities Singapore, n.d.)

Powered by Infocomm (information and communications network) and extensive intelligent network, iNation vision strives to (iN2015 Steering Committee, 2015): /Innovation: the creation of innovative Infocom enterprises to renovate and rebuild existing urban modules /Internalization: facilitating access to global resources, ideas, products, and talents and /Integration: providing the ability to harness data/information capabilities among city organizations and community start-ups. By doing so, this vision hopes to enrich the serviceability and adaptability of intelligent resources for its citizens (iN2015 Steering Committee, 2015). (See Appendix 3_A)

Today, Singapore has a high ranking of economic, governance, ICT connectivity indices. According to "Asian Green City Index" which delineate the success factors 22 major Asian cities Singapore ranked first in many domains including "carbon dioxide (CO2) emissions, energy consumption, environmental friendliness of buildings, urban transport and mobility." (Sanserverino, Valentina, Macaione, & Sanserverino, 2017). Singapore's legacy for infrastructural planning has been a leading actor among counties, with the broad focus of development from traffic management, environmental quality, and flood mentoring and water management (Ho, 2017).

- Smart Mobility

In order to address the continuous demand for public transportation, the city maximized the capacity of road networks through intelligent transportation solutions. The Singapore

Transport Authority (LTA) by partnering with IBM Business Groups, created distance-fare pricing systems (electronic payment system) to ensure seamless and cost-effective travel experience within the city for residents. The system utilizes intelligent algorithms "to charge a single fare based on distance rather than the number of transfers." (IBM Industry Solutions, 2013). By offering affordable public transportation services, this model attracted more commuters to use fast-train and public buses. (IBM Industry Solutions, 2013).

The Land Transport Authority (LTA), a city department on transportation created convenient mobility schemes to ease traffic congestion and foster public transit. "The Metro Line" and "Parking Coupons" are only a few examples of its efforts. The recent project focuses on Mass Rapid Transit as critical nodes of transportation to connect the main routes throughout the city, and the former one is the Electric Road pricing system which regulates the traffic through identification checkpoints. (Sanserverino et al., 2017).

According to C40 Report the 'intelligent blueprint' shaped by "a number of innovative approaches aiming to engage citizens were used, including focussed group discussions, online feedback on the Talk2LTA portal, and the Great Transport Challenge e-game, from which the insights obtained by players were taken into consideration in the masterplan." ("C40 CITIES," 2018). Also, these moves around smart mobility especially self-driving public transit which seek to extend automation in plans and utilities, allow more flexibility to incorporate smart vision goals in a wat that Dr. Gelsin, a managing director at LTA specified that: "…Singapore's strong support of the technology and legislation for driverless vehicles should encourage an increase in the patronage for self-driving transportation, leading to a reduction in private vehicle traffic and the associated pollution, making the city cleaner and safer for its people" which to that end these mobility programs are expected to optimize routes, increase the safety of commuting and reduce traffic congestions…" ("Smart Nation Portrait: Singapore," 2018)

- Smart Environment

With the supervision of Infocomm development authority (IDA) and Urban Redevelopment Agency, the "Jurong Lake District" is planned to be one of a lakeside commercial hub for the development outside the city center. ("Jurong East Today - Untapped Potential," n.d.). The district planned to upscale neighborhoods economic vibe

by focusing on mixed-use activities that cater business in several fields including leisure and tourism, urban parks and eco-city, parks, waterfronts and gardens (Figure 3-3 and 3-4). Also, with the agreement of the IBM corporate citizenship program, the district has received continuous financial support to the development of urban waterfronts and Infocomm major R&D. (Sanserverino et al., 2017). As part of the district vision, IDA implanted "Smart Health-Assist" to support for the public services for aging population The model record data from household sensors from patients suffering from chronic diseases and send the data to relevant healthcare providers "allowing them to monitor individuals, receive alerts, and respond to any emergencies". (Keon et al., 2016).

Infrastructure wise, the iNation extended the high-speed fiber systems in the Jurong district for providing reliable accessibility through enabling cloud/edge-computing and big-data as well as connectivity to public and governmental data for co-creation of people-centric solutions (Hoe, 2016). Also, "Government Cloud (G-Cloud)" and "Intelligent Energy Module" (Figure 3-5) under the scope of "Infocomm Security Masterplan", created to assist "national-level attempts to secure its country against any external or internal cyber-threats". (Keon et al., 2016). Within these efforts the government puts on emphasis on 'experimentation and risk-taking' and 'independent citizenry' to promote ICT-talents and skilled individuals to fill the emerging positions in the domain of optimization specialists, social media managers and application developers (Hoe, 2016).

Speaking of data-analytics and urban simulation tools, Singapore launched "Virtual City" platforms. This multi-purpose city-scape tools act as virtual models, enable the architects and urban designers to fully capture and understand the urban/environmental factors in 3D simulated digital models (Figure 3-6 and 3-7). This data-rich modeling program creates an informative platform to assist decision-making in areas of resource management and urban design ("Virtual Singapore," n.d.). Also, as a part of Virtual Singapore objectives, urban innovation design studio extended the top-down master planning vision of the city through the use of parametric software and data generated master plans to consolidate a set of data streams (like topography, building masses, microclimate data,etc.) for creating visionary architectural maps. For example, a city designer can perform air quality visualizations to

predict the outcome of a specific type of microclimate condition or assess solar potential analysis for individual buildings for the proper placement of solar panels.

A few capabilities of these simulation tools may refer to ‘virtual experimentation’ (for analyzing the coverage of wireless and 4/5G networks through realistic visualization), ‘test-bedding’ (for validating the provision of community services such as sport hubs or public reunions with semantic data to predict the crowd dispersion, evacuation paths, etc.), and city planning (simulating the transportation flows and pedestrian movement patterns in parks and public places). (“Virtual Singapore,” n.d.)

Figure 3-3 Part of the development at Lake District Singapore, https://www.jld.sg/

Figure 3-4 Supertree grove steel and reinforced concrete structures designed with gigantic canopy frames that create fascinating daily shadows nightly light displays located in the Marina bay garden (right). One of the most iconic resorts and hotel complexes Marina Sand Hotel, which has been ranked as one most booked hotels by tourists that integrated with several smart devices like smart apps ad RFID sensors. https://hub.beesmart.city/city-portraits/smart-city-portrait-singapore

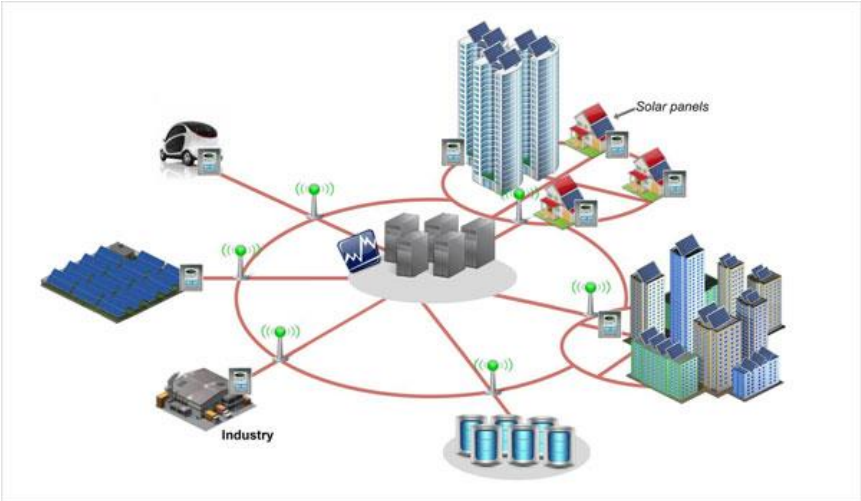

Figure 3-5 The model of Intelligent Energy System pilot, the platform supports vital infrastructure components such as the smart metering and communication systems. https://www.imda.gov.sg/infocomm-and-media-news/buzz-central/2010/10/intelligent-energy

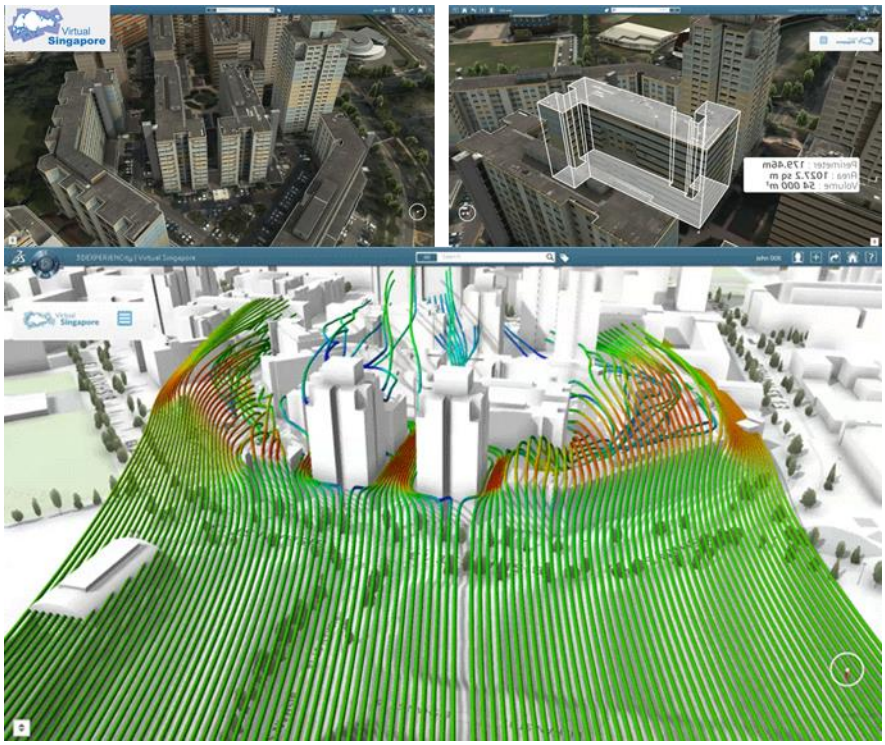

Figure 3-6 An example of wind simulation project to analyze the proposed building topologies against environmental conditions of the surrounding buildings. https://www.smartnation.sg/what-is-smart-nation/initiatives/Urban-Living/virtual-singapore

Figure 3-7 An example of a parametric master plan provided by Virtual Algorithmic Models for JLD project, https://www.jld.sg/

3.3 Amsterdam, Netherlands

According to Somayya & Ramaswamy (2016), "the idea of the Amsterdam Smart City is to go from a traditional "knowledge-silo-thinking" to a holistic information community, where synergies are created through cooperation." (Somayya & Ramaswamy, 2016). The underlying approach for the Amsterdam Smart City (ASC) is the importance of the inclusive and knowledge-shared city that designed in such a way that promote citizen activities in urban places such as shopping, public transportation, and walkable districts (See Appendix 3_B). In partnership with Amsterdam Innovation Motor and Grid Operator (Liander) company, the city launched "City Smart Project" in 2010 (Somayya & Ramaswamy, 2016). This smart initiative in close collaboration with Amsterdam Municipality provided new models for energy-consumption strategies within and between Amsterdam districts. Currently, more than 80 active partners are working in several municipal services, including healthcare, energy, transportation, and smart government (Angelidou, 2016; Somayya & Ramaswamy, 2016).

ASC plan emphasizes on simplicity and transparency in which all partners (Alliander, KPN, Accenture, IBM, etc.) took on long term economic plans to renovate urban systems and improve the IT quality services. In fact, creating strategic partners among several stakeholders (i.e., enterprises and civic groups) ensure longevity and dedication among actors. As Sanseverino et al. (2017) suggest: "The involvement of public administration is essential; in fact, it creates confidence in the achievement of objectives, ensuring open data, long-term commitment, targeted policies, and leadership." (Sanserverino et al., 2017)

- Smart Environment

"Almere Smart Society", a key example of a socially-focused initiative created by noted firms such as IBM, Philips, and living Plan IT in order to facilitate the integration of intelligent services and IoT technologies for urban planning and natural resource management. ("Almere Smart Society," 2015). An official representative of ASC states that "the Almere Smart Society vision involves the realization of an IoT facility, which, amongst other things, will promote the more efficient urban management, innovation, and economic growth, strong social cohesion and sustainable development" (Somayya & Ramaswamy, 2016). Another active project in the area of urban water management is

"Amsterdam Rainproof", aiming to stimulate civic groups and environmental firms to create an interactive platform for solving issues around water run-off, flood mitigation tools, and sustainable water strategies. (Somayya & Ramaswamy, 2016)

As a part of open data and shared community portals in the field of tourism and mobility, the "Smart City SDK", has been launched to address the underlying potentials of using data, and open-source datasets for public decision-making ("Amsterdam Smart City," n.d.). Creation of this city-wide open data service promoted the open data exchange projects between IT developers and municipalities and created dynamic channels for developers to offer customized applications for urban mobility paths and green buildings diagrams. According to Spaan, the developer of cultural heritage project in the CitySDK project, such open-data portals enable the visual insights for the testing and offering suited proposals in every part of the city. As an example, "an app provided to predict buildings age according to their year of construction, which gives a completely new image of the country and clearly shows the age of cities, whether they are still relatively young (in blue, built after 1960) or very old (in red). A nice example is a city like Haarlem, of which the old inner-city lights up, or Almere, covered in blues as it is built in recent times." ("CitySDK - Amsterdam Smart City," n.d.) (Figure 3-8)

- Smart Mobility

"Vehicle2Grid", the intelligent cooperative initiative is another project, which launched by community members to implement using electric vehicles and e-bikes with household energy usage (Somayya & Ramaswamy, 2016). Through the support of programs, residents can use battery-powered storages in their cars for short routes and at the same time, connect their storage in the homes. The energy can be transferred to the gird, or it can be used locally. (Somayya & Ramaswamy, 2016). In the same focus, "Ship to Grid" project includes 70 electricity storage/distribution units on the banks of the river to provide continuous power for moored boats for tourists and freight transport.

"The shore power is available through connections that use a pay-by-telephone system. With a single telephone call, the captain is able to activate a connection with the shore power station by entering his code. The connection is deactivated by logging off or plugging out at the connection point, and the amount of money owed will automatically be

transferred from the vessels account. The CO2 emissions from the used renewable energy are minimal." (Sanserverino et al., 2017)

Another project on the use of virtual design platforms and autonomous devices is the 'Design Boom', an interactive 3D visualization map of Amsterdam's canals (Figure 3-9). With the collaboration of "senseable city lab" at MIT and Amsterdam Advanced metropolitan solutions (AMS) (Marchese, 2019), the team strived to create on-demand infrastructure (enabled by data collection) that combine autonomous platforms with the city's urban systems, waterways, transportation routes, etc. By using autonomous boats and artificial intelligence (LIDAR technology with 3d drones) the team could create a virtual representation of surrounding landscape from the millions of data points and images captured with these robots to provide a sensible model of water canals (Marchese, 2019). One of the aims is to facilitate the transportation on underused channels to ease the congestion on busy streets, to calculate efficient routes, and to predict possible water disturbances and environmental conditions. To that end, these pictorial representations of Amsterdam's cityscape further emphasis on the role of smart devices to get some richer insights on the city's infrastructures.

- Smart living

There are a couple of projects which aimed to create tangible collaboration with residents and civic groups ranging from the smart building (the "City_zen") to intelligent shops (the "Climate Street Project") See Figure 3-10. These residential and commercial civic zones offer green technologies and energy-saving utilities (smart meters, sensor displays) to transform consumers' behavior to informed-energy users by reducing their carbon footprint and fossil fuel consumption (Angelidou, 2016). Waag Society, another user-oriented initiative, is an active civic hub that promotes artistic research, educational symposiums, and social events that emphasis on active participation and knowledge sharing. (Sanserverino et al., 2017).

The "Green living lab" as a showcase of a sustainable living practice, initiated with by the efforts of landscape architects and AKKA (architectural firm). Their architectural philosophy lies on "architecting interaction" which strive to explore the human interventions on creating tangible spaces for meaningful responses of places that "focus on

designing the contexts in which interactions emerge and blossom" like urban ecological design and urban community gardens through the dedication to nature and cultural exchange ("Amsterdam Smart City," n.d.) Figure 3-10. AKKA simply noted on interaction as: "We believe that space is a strategic tool that can foster interactions, and any added value or innovation, small or large, starts with interactions. Interactions are the seeds of innovation. At the intersection of the main forms of interaction – creativity, collaboration, and learning –added value emerges…interactions are spontaneous and context-dependent, which means they cannot be designed, nor should they be forced. Instead, we focus on facilitating interactions by designing the context in which interactions emerge." ("Approach - AKKA Architects," n.d.)

The Green lab promotes the connection of an individual with the urban character through direct interaction and educational practice, creating a synergy for a healthy lifestyle and social interaction ("Amsterdam Smart City," n.d.)

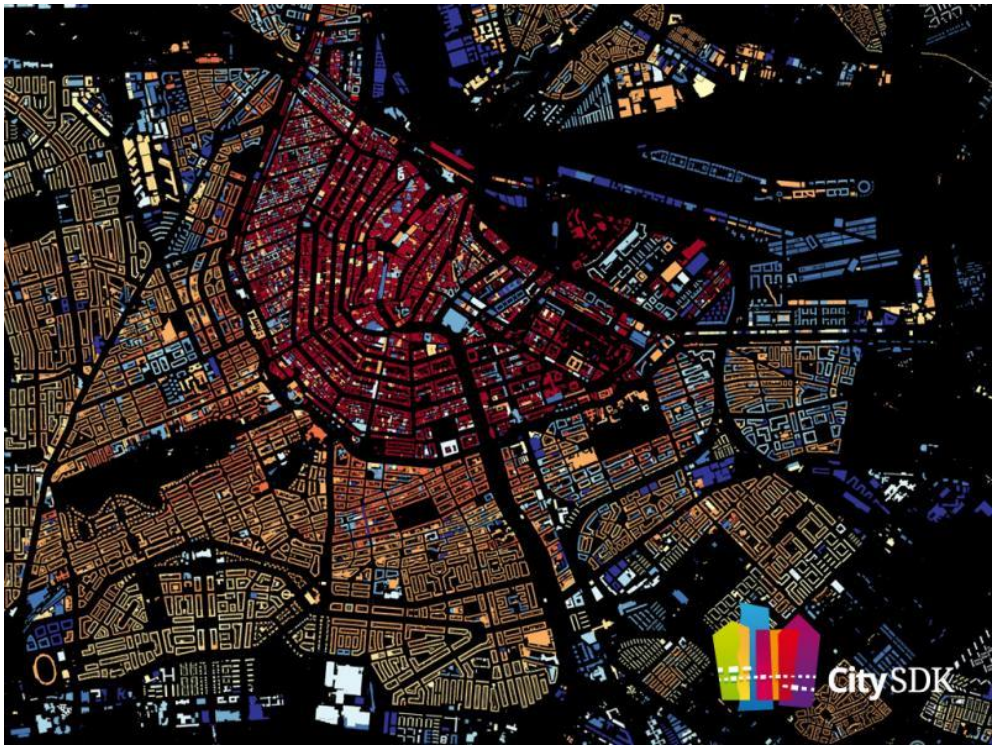

Figure 3-8 City SDK Data Portal, Amsterdam provides " services that can help open up data in the fields of Participation, Mobility, and Tourism", the color-coded map shows the age of buildings in a district. https://waag.org/en/article/map-shows-age-dutch-buildin

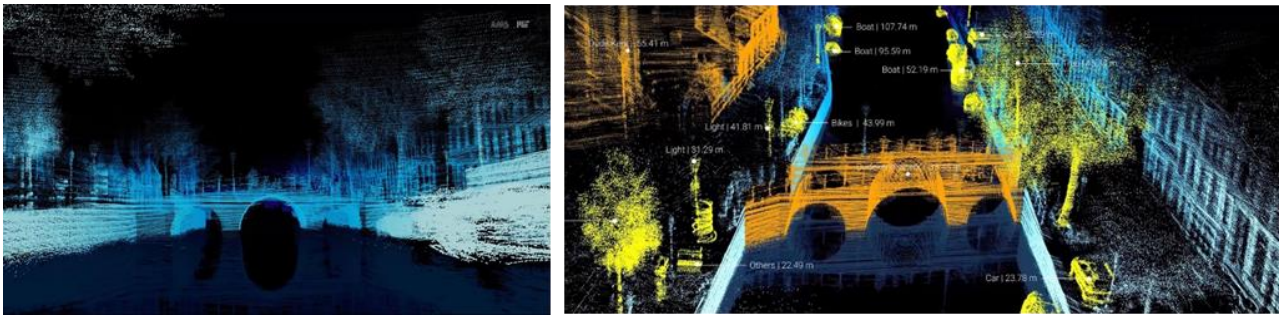

Figure 3-9 3d point cloud mapping of Amsterdam waterways through using AI and advanced visualization tools, https://www.designboom.com/technology/mit-roboat-laserscape-amsterdam-canals-01-30-2019/

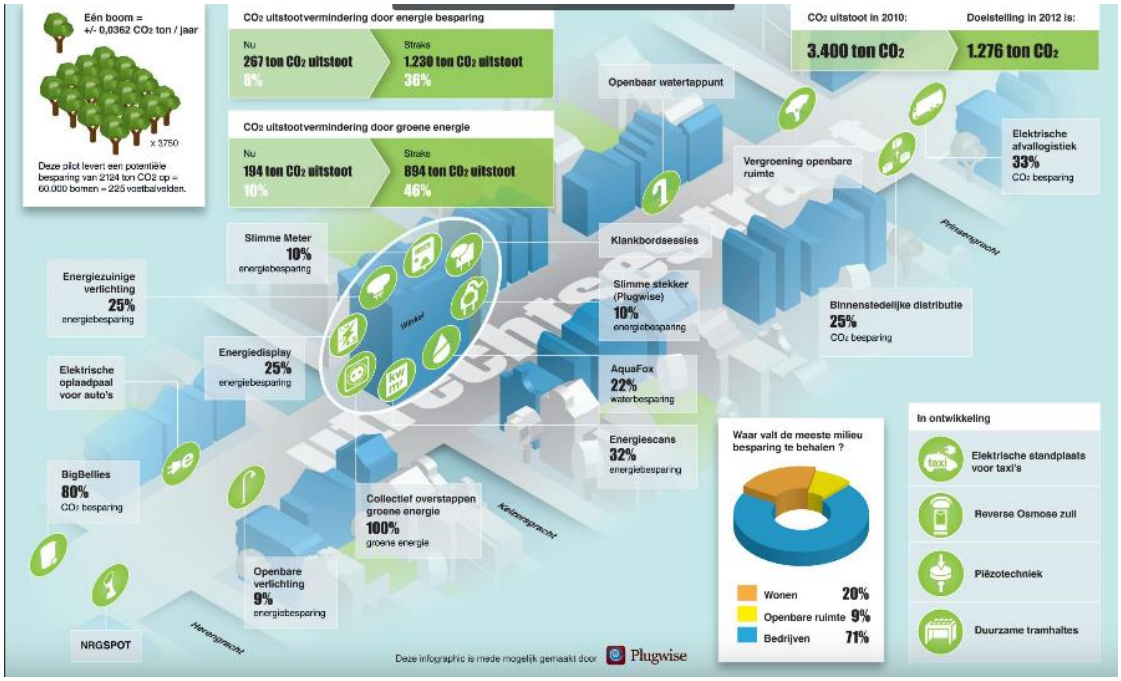

Figure 3-10 (Climate Street) initiative, conceptual objectives, https://amsterdamsmartcity.com/projects/climate-street

Figure 3-11 Designing with nature, the green laving lab in Amsterdam, https://greenlivinglab.org/

3.4 Stockholm, Sweden

Stockholm has proved focus on research and innovation for information technology and environmental planning. It is considered to be a well-established, livable, and resilient-focused city that provides a high standard of living and swift government services (Angelidou, 2016)

Stokab, a publicly owned-project in the area of ICT development, offered 100% broadband and networked-web commutation platform with the Stockholm Region (Angelidou, 2016). The network extended from the "city's financial center to the rest of the region" (Angelidou, 2016; Ching & Ferreira, 2015). It is one of the largest communication networks in Europe (Stokab, n.d.). through testing and utilizing city-wide connection via Stokab and major IT-firms, the city creates "a flourishing ecosystem that involves the city inhabitants, the private industry and the public sector while fostering a dynamic local economy." (Angelidou, 2016). The city's smart strategies revolve around citizen connection with administration and governance services where City Hall Module, Mobility Plans, and Krista Science City are considered to be initiators of e-government and open-data portal services. (Angelidou, 2016; BIS, 2013), See Figure 3-13

As BIS report states: “A creative melting pot in Stockholm where companies, researchers and students collaborate in order to develop and grow. The foremost sector in Kista is ICT… Ericsson, Microsoft, and IBM are just some of the major ICT companies to have established a presence in Kista Science City. There are also over a thousand other ICT companies of all sizes. 6,800 students are currently studying ICT courses at Stockholm University and the Royal Institute of Technology in Kista Science City.” (BIS, 2013)

The Stockholm 2030 Vision used research method called “Design Fiction” plan to elaborate on future city goals and visions in part of its vision necessitate the core combination of smart technology with daily human activities. Though a bit provocative, some insights represent high tech services which will be embedded in ordinary urban platforms like facial recognition equipment in public buildings, virtual reality modules for car/user pathfinding, and online-learning institutions (Eden Strategy Institute, 2018)

In Stockholm 2030 vision plan stated that “Beyond its smart and connected city strategy, Stockholm used a research method called Design Fiction to imagine the city’s development. This method aims to explore futures by creating speculative – and often provocative – scenarios about the future.” (Eden Strategy Institute, 2018)

- Smart Environment

Located in the Nora Djurgårdsstaden district, the Stockholm Royal Seaport is one of key projects there still under construction (The City Planning Administration, 2018). The initial efforts of the district are to reach environmental protection goals through reduction of fossil fuels, improving water harvesting infrastructure, and renovating ICT and smart grid capabilities in the households and commercial sites (BIS, 2013) (Figure 3-12). Doing so, the initiative strives to improve “the vision and environmental policy objectives for the urban district”, and creating urban labs “focusing on issues concerning strategically smart living climate and innovations for sustainable urban development”. (Sanserverino et al., 2017).

As part of the project Värtahamnen neighborhood targeted on mixed-use development scenarios, planned to provide over 1000 residential units and 3000 new jobs for the community (The City Planning Administration, 2018). Another focus in the field of historic

preservation is Slussen, a traffic juncture on the heart of Stockholm, which is considered to be one of the historical landmarks in the area. Due to its vulnerable infrastructures, old buildings, and inefficient road connections, the city administrators initiated the Slussen revitalization project in 2014 with the design proposal of Foster and Partners (Figure 3-14). With the mixture of cultural attractions, green spaces, and vibrant public spaces the new development program (master plan) for the area emphasizes on the replacement of old structures with new modern intelligent spaces, shared commercial buildings and efficient pathways for pedestrians and connected boat sites on the lakeside of Malaren. According to SEK report: "Slussen will be rebuilt to become an effective and safe juncture for both pedestrians, cyclists and public transport. The aim is to turn it into one of Stockholm's most attractive meeting spots with cultural events, entertainment venues, parks, restaurants, and cafes." ("Slussen - City of Stockholm," n.d.)

- Smart Mobility

Stockholm has a long tradition on developing public transportation network including bus, trains, and metro stations. Public transport is quite responsive throughout the city in a way that nearly 70% of the commuters use buses, suburban trains, and shared EVs and E-bikes on a daily basis (Figure 3-15). Also, the city launched a few pilot mobility stations to accelerate the transition on low-carbon community models via sharing hubs and bike stations located in KSC and Helenelund areas. (The City Planning Administration, 2018)

The strategic plan of the city aims for the proper use of public spaces and connecting infrastructures and business sites. A municipality report referred to a mobility scheme as:

"The strategy has a clear link to the City Plan in that it addresses how urban environments are experienced and used and the role of city planning in influencing the distribution of means of transport. The strategy is translated into action in individual plans and programs, including the Bicycle Plan and the Road Safety Program". (The City Planning Administration, 2018)

Figure 3-12 Birds Eye View of Stockholm Royal Seaport District, http://www.stockholmroyalseaport.com/

Figure 3-13 Community workshop in the climate-smart initiative, https://xn--vxer-loa.stockholm/tema/medborgardialog-och-samrad/

Figure 3-14 Part of the visionary plan for the development of Slussen Area, Stockholm
https://international.stockholm.se/city-development/slussen/

Figure 3-15 Electric charging station and EVs at Helenelund/Kista, developed by NEVS (transportation company) and Toyota. https://smartcitysweden.com/focus-areas/smart-mobility/

CHAPTER FOUR

4 CASE STUDY ANALYSIS

Following the preliminary introduction to smart city cases and their smart initiatives, this chapter elaborates on the analysis of each case. The discussion will continue around the three main themes/domains of smart cities:

Domain 1 – Information and Technology-Oriented Approach

Domain 2 – Service-Oriented Approach

Domain 3 – Application-Oriented Approach

In order to highlight the central values, each case will be synthesized according to specific aspects, such as underlying aspirations for smartness, partnership streams, focus areas of their practice, engagement activities, as well as nature of initiatives (such as community-based or location-based). As noted earlier, due to the diversity of smart initiatives/firms, the acquired list is non-exhaustive and only can be used for illustrations of specific approaches or particular services offered through projects in each city.

4.1 Domain 1 – Information and Technology-Oriented Approach

Smart cities employ ICT and intelligent systems to acquire benefits from smart functions (Kitchin, 2014a). While this case is valid for Singapore, not the other cases directly apply ICT as smart tools. Also, this domain of the ICT-orientation suggests that the

reorganization and change (in a city-level agency) should be a part of smart integration to obtain the desired outcomes. For example, a traffic modular point service and integrated center, in Singapore, used as a prediction of traffic flows (Keon et al., 2016). By using generated algorithms, the system predicts/models the future traffic patterns and conditions, which is not obtainable in a conventional manner (Sanserverino et al., 2017). The LTA officials reported that the model could accurately predict traffic volumes, which mitigated the traffic congestion and reduced costs of traffic delays (IBM Industry Solutions, 2013; Sanserverino et al., 2017). In Amsterdam's ASC, the collection of urban utilities with ICTs infrastructure improved the quality of services offered by initiatives in energy distribution, traffic control, and e-commerce services. For instance, utilizing smart meters, charging units, RFID and IP traffic cameras improved the efficiency and responsiveness of public services, as well as providing secure access to data and available information via government portals (Somayya & Ramaswamy, 2016).

Besides, the functions of these cases require setting up prerequisite modules for processing and analyzing the data (IBM Industry Solutions, 2013). As of Singapore, first, it may include climate sensors, security cameras, and embedded GPS units in vehicles, etc. (Keon et al., 2016). Second, the gathered information should be transmitted, organized, and integrated for specific tasks, following visualizations or results to facilitate the analysis. These functions seem to revolve around short-term urban operations (BIS, 2013), which display some necessary procedures. Yet, it is still under question that in case of emergency, how these systems are able to reconfigure and respond promptly. Some of these points have been addressed in Singapore's data safety and security programs, in which cyber-security functions/models are pre-planned and installed in the early stage of ICT implementation to ensure data protection and citizen's devices safety, resulting in richer acceptance of cloud technologies in everyday life of citizens (Angelidou, 2017; Hoe, 2016).

In response to organizational changes, other cases (like City Hall Model in Stockholm), appears that they tend to take an incremental approach rather than drastic changes. Specifically, nascent initiatives require more time and resources to develop (the case of "Climate Street" and "Digital Media" street in Amsterdam) (Lee & Hancock, 2012). These settings can be done through extension procedures to the existing departmental workflow

models (Angelidou, 2014). Also, Singapore iNation program provided greater opportunity to take on holistic integration of smart applications in organizational structures to fully capture the outcomes of smart integration (Centre for Liveable Cities Singapore, n.d.). In such a case, the technical barrier is not the only limiting parameter, and the more straightforward implementation reflects the priorities of the project. For example, in Stokab's fiber network, a city department can either harness ICT and smart features for streamlining its processes on the surface level or create new innovative functions for city services (Ching & Ferreira, 2015; Keon et al., 2016).

While this research only picked three cases, further investigation is required to evaluate the results of 'smart system integration in city infrastructures' against conventional methods. Another question is whether smart system integration can be applied for long-term operations or not. In the next chapter, a few notes will be explained concerning this factor.

4.2 Domain 2 - Service-Oriented Approach

Considering the community-sharing environments, each case has been actively engaged in providing possible think-thank groups and knowledge pathways in their smart projects. Among them, the use of scorecards and performance criteria facilitated the knowledge-sharing via conferences, outreach services, and community events (see Figure 4-1). Amsterdam Smart Project and Singapore iNation actively engaged in regional events and conferences, like the recent smart city "Smart Nation Innovation" events where cities shared the tested/untested solutions in the context of intelligent city services (Eden Strategy Institute, 2018).

Figure 4-1 Smart city efforts in learning and knowledge-sharing events (compiled by Author)

Alongside creating collaborative networks, Stockholm initiated the "climate-smart and resilient city" programs that seek new opportunities for idea sharing, like urban energy transition policies and green infrastructures strategies (The City Planning Administration, 2018). In a similar case, Singapore hosted multiple visits within the context of "resilient-city", "eco-city", "urban ecology", and "smart nation" practices (Centre for Liveable Cities Singapore, n.d.; Ho, 2017). Also, the "Amsterdam Citizen's Lab" and "Stockholm Resilient Center" served as a supra-national platform for city managers and ITC experts to address resilient and smart city potentials and as a showcase for their smart efforts. The "Kista Science City" as part of Sweden ICT-cluster provided collaborative-workshops in other cities (Angelidou, 2016). They hosted several commissions, as well as multiple events in cities in EU countries. The customized visits directed toward experience sharing in areas like ICT instrumentation, green governance, water management, etc (Shahrokni et al., 2015). As European smart city council states, the collaborative partnership created "transferable knowledge stream" among enterprises that encourage green business opportunities (Angelidou, 2016), and these examples among several others provided conceivable avenues for knowledge sharing and co-creation of district-based solutions.

In terms of using evaluation metrics, this research was not aiming to provide quantitative results. However, it is evident that in most cases, cities utilized the assessment measures

and benchmarking tools[11] (IBM Industry Solutions, 2013) to evaluate the performance of their smart initiatives. Use of metrics is also dependent on the type of the projects, the goals of smart enterprise, and organizational policies (Albino et al., 2015) which to that end, help the agencies in up-scaling and implementation of their smart efforts. The Amsterdam's Alma Smart Society efforts elaborated on key performance indicators to assess multitude of social/environmental variables (such as the amount of CO2 reduction, citizens' involvement in the decision-making process, number of generated entry-level jobs) to track each project and provide transparent agenda for partners and investors (Angelidou, 2014; Lee & Hancock, 2012).

The feedback loops are also embedded in multiple levels to facilitate the up-scaling of smart initiatives (Manville et al., 2017). Feedback on each service started in a small-scale pilot project and shared among stakeholders. For example, in "Amsterdam's Automated Water & Smart Meter" cases, the community members expressed negative feedback about the low subsidization on water utility meters (Lee & Hancock, 2012). The residents advocated that the scheme of the current tax regime may not allow them to exchange energy produced, resulting in inadequate funding for the project (Figure 4-2).

[11] Benchmarking metrics and softwares allow a city to quickly evualute and assess its potentials (like SWOT analysis) according to city's smartness crtieria and visions. A few examples;
Resilient Dashboard for Cities: "An approach to designing, planning, and managing for resilience, including evaluation of cultural and process dynamics within cities"
Source: https://m-cacm.acm.org/magazines/2016/8/205032-smart-cities/fulltext?mobile=true
IBM Assessment Tool: "A tool to measure a cities performance, perform scorecard models, and identify challenges and opportunities for improvement on multiple themes: civic life, economic life, mobility and transport, energy management, water management,..."
Source: https://m-cacm.acm.org/magazines/2016/8/205032-smart-cities/fulltext?mobile=true

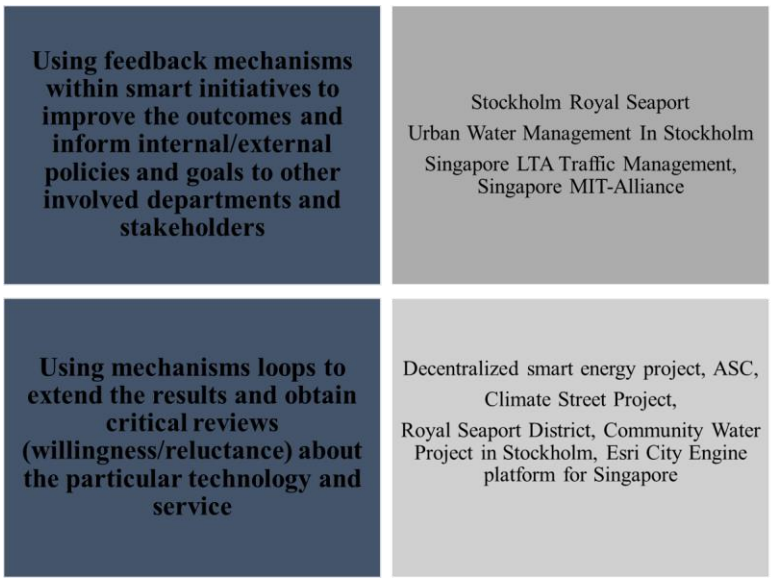

Figure 4-2 Using feedbacks mechanisms in the studied cases (compiled by Author)

A positive side of Royal Seaport in Stockholm is its potential capacity to redesign, change, and promote specific services thanks to the feedback mechanisms. Due to the period of the project and elongated time-frame, the deployment of ICT-services needs to be aligned with the current issues of the district to address the disruptive changes promptly (Shahrokni et al., 2015). For example, a few community projects on water management and flood resilience mobilized the community practices to provide in-advance notices for potential interventions on flood control, which showed the value of knowledge sharing among citizens and even protect neighboring cities from flood threats (Chelleri et al., 2012). In addition, the RSP officials activated the "Urban Metabolism Lab", as a platform for engineers, designers, and citizens to "develop low- cost, easy-to-build-and-maintain sensor kits to measure temperature, humidity, light, sound…" (Eggers & Skowron, 2018) and other environmental practices to share in online learning platforms like Coursera (Eggers & Skowron, 2018; Shahrokni et al., 2015)

The extension of feedback mechanisms beyond the scope of an agency could provide more extensive benefits. For example, in Singapore's water management case, the early warning system has been deployed through feedback models (for the installed rainwater catchment, water recycling, and desalination) (Ho, 2017; Lev-on, 2013). The adjustments to existing physical infrastructures help the upscaling or commercializing the smart initiatives for a longer-term prospect according to objectives of the community project.

Smart city practices include collaborative processes and participatory platforms (Commission, 2014), where city officials engage with businesses, research institutions, and community groups to promote innovation and partnership. One of the motivations for stakeholder engagement is creating a "flourishing ecosystem" among private industries and civic groups (Angelidou, 2014). In general, all the examined cases utilized various forms of practices through collaborative partnerships and leveraged local human capital via community meetings and gatherings. One of the merits of this type of connections is flexibility. Private companies and local start-ups tend to more agile and responsive in face of change due to less regulation and restriction. For a private sector this is a huge opportunity to be the pioneers in the smart market. The summary of the key partnership efforts is provided in Figure 4-3.

Smart initiative cases/City departments	Community groups / Civic Workshops	Research institutions/Academic Sector	Business sector/Technology Providers
Kista Science City	Community inputs and services through apps and web-based portals	TU Delft, KTH Royal Institute of Technology	Local non-profit organizations, Philips, Ericson, etc.
Jurong Project, Singapore	Community feedbacks on e-government services and education, and healthcare	National University of Singapore (NUS)	EDB Singapore, IBM
Stockholm Royal Seaport, Stockholm	Civic feedbacks on energy solution and data collection platforms	KTH Royal Institute of Technology, Stockholm Universty	Ericson, Fortum, Cisco, etc.
Stokab, network infrastructure, Stockholm	-	Swedish ICT	Both city agency and technology provider functioned by Stokab
Citizens Lab and Climate Street, Amsterdam	Civic feedbacks and strategies on energy planning and local financing, circular economy	University of Amsterdam, Vrije Universiteit	Cisco, IBM, and private owners (e.g. airports, hotels, etc.)

Figure 4-3 Different partnership streams in the smart city cases (compiled by Author)

In Amsterdam's ASC case, the triple (and quadruple)-helix co-operative model (Ching & Ferreira, 2015) used between industries and research institutions (see Figure 4-4). In this model universities, enterprises, and governmental agencies work together to promote the bottom-up interventions and as Leidesdorff and Deakin (2011) stated the module is the product of carefully constructed policies and agenda that aid cities into more responsible practices (as cited in Krishna, Kummitha, & Crutzen, 2017). Hence, ASC acted as a central point by bringing the technology providers and communities to implement and formulate new ideas for pilot practices according to the needs of smart initiatives. According to ASC:

"an open and collaborative mindset coupled with favorable government regulations has facilitated an entrepreneurial spirit, which has engaged a high number of stakeholders both inside and outside of the city. Such broad engagement and strong support networks provide firm ground for the piloting of innovative ideas and projects, and has ultimately led to the formation of a whole *ecosystem of smart city solutions*…" (as cited in Smith, 2017)

For the Stockholm's KSC and SRS projects, the collaborative environment represented through citizen-focused efforts and access to government services where residents have access to real-time information about traffic indicators and air quality measures (Angelidou, 2014). Also, the city released a set of data portals and city dashboard infographics as part of open data exchange and policy (See Appendix 4_A, B). The data contains traffic densities, public transport schedules, and government services ("technology and society | Waag," 2015). A few apps like "SRS Dashboard" and "Urban Metabolism Sankeys" has been used for this purpose to provide real-time data access (Eggers & Skowron, 2018; Shahrokni et al., 2015).

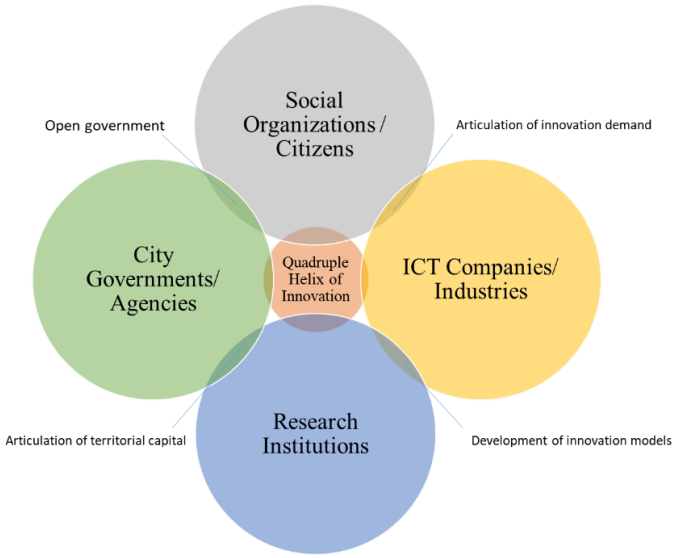

Figure 4-4 Representation of quadruple-helix model of innovation for smart cities, adopted from Krishna et. Al 2017, drawn by Author

In Singapore, Infocomm's collaborative agenda emphasizes on secure ICT-shared environment for city agencies and technology firms following by matchmaking role and social-networking platform among beneficiaries (Hoe, 2016; Keon et al., 2016). For instance, in the Jurong Lake project, several tech-actors in the area of entertainment/digital media and education launched a visual-learning digital marketplace for the content creation

and commercialization of new interactive learning models (Angelidou, 2014) such as virtual reality and artificial intelligence[12] through public workshops (See Appendix 3_A`). Such events provided potential sources for new ideas and led to greater cooperation among community members and industries (Fitzgerald, 2018). These samples give a hint into the concept of "city-as-a-platform," (Eggers & Skowron, 2018) which shifts the governmental practices from "doing things to enabling participation and delivery." (Eggers & Skowron, 2018).

While the above examples are not complete, it reflects the diversity of partnership approaches taken by smart initiatives. One requirement is the necessity of the ICT firm in the (partial) involvement of a project/service. Furthermore, the role of research institutions need to be broader, as they are able to provide top-notch and viable solutions/ideas to businesses and technology actors such as Swedish ICT in test-bedding and R&D sector of the Royal Seaport Project (Shahrokni et al., 2015) or National University of Singapore engagement in hackathons and community events. The above note also raises questions concerning the level of involvement among different stakeholders.

For instance, some smart projects require higher collaboration with technology providers due to the readiness and availability of the procedures for better implementation of smart practices. This case is apparent in Singapore's Intelligent Energy Project (with the Alliance of Massachusetts Institute of Technology (MIT), Nanyang Technological University (NTU), and IBM) to renovate and expand smart-grid solutions and to create "two-way communication units for electricity consumers and grid operators" (Rodríguez-Bolívar, 2015). While, other cases like community driven-efforts in Stockholm's Kista Science City (for developing mixed-used commercial streets and green shops), need to emphasize on the mutual involvement of research institutions (KTH University) and civic workshops/meetings in the neighboring areas to acquire positive inputs/data for the imitation of projects (The City Planning Administration, 2018).

[12] "computer systems that can perform tasks previously considered to require human intelligence: visual perception, speech recognition, decision-making, translation between spoken language…". they can automate tasks/process through human inputs and learn and adapt themselves via iteration and self-practice, source: https://www.cimconlighting.com/what-is-a-smart-city

4.3 Domain 3 - Application-Oriented Approach

Regarding partnership frameworks, smart initiatives have taken multiple forms of bottom-up and top-down approaches. Also, the extent of engagement among partners (community members, city agencies, and technology sector) can differ within each case. In Singapore's case, smart partnership revolves around the top-down vision. The JLD and LTA, partners involved in the formulation of agenda-setting (Sanserverino et al., 2017). For example, Infocomm focused on ICT modules and backbone infrastructures such as fiber-networks (Ching & Ferreira, 2015), while Transport Authority practiced the applicability of smart solutions like sensors and meters in traffic information and analytics. Following that, the city government set out the goals/plans to firms. By implementing centralized solutions, infrastructures are integrated, monitored, and resources can be optimized in a way that maintenance measures can be pre-defined. Here, the process does not solely fall in top-down approach because there seem to be an openness and flexibility in idea/goal setting from community feedback. In this case, the top-down approach provided facilities that integrated various inputs (such as water sensors, predictive analysis, notification interfaces, user-generated data, etc.) and re-arranged the initial orientation and their processes to include more comprehensive data-driven services.

Angelidou (2014) states the facilitative role of government in creating an active arena for the innovators, city artists, and entrepreneurs; allow the promotion of community feedbacks to projects. The obvious example of this is the city open data approach, public workshops, and hackathons events, which encourage openness to new models and challenges old-forms of ideas (DuPuis NStahl E, 2016). For Amsterdam, due to the collaborative nature of smart projects, the city lies on the bottom-up format. Amsterdam Smart City has provided a vast pool of technology suppliers in initializing and implanting smart solutions in terms of socio-economic and environmental objectives. Thus, the nature and extent of each project are unique, and such a diversity require the engagement of multiple partners and stakeholders. For example, in 'Climate Street' project more than 10 actors engaged in the test-bedding process, including 'Liander', 'Club Van 30' (business consultant), 'Vodafone', 'PostNL', and local stakeholders ("Amsterdam Smart City," 2014).

The overview of smart city cases showed that some of the initiatives mainly chose top-down platforms, where city agencies had a leading role in framing the goals and targets of smart practices (such as using web-based apps to improve city services, allocating a specific location for test-bedding of projects, etc.). Compared to a top-down approach, in which the city governments have a primary role in conceptualization and initiation of smart practices (Breuer et al., 2014), the half-way model between top-down or bottom-up approach is the middle-out framework (see Figure4-5). As Suzuki (2015) states that "this approach combines both a top-down and a bottom-up approach, the latter of which is emerging from communities advancing innovation and industry creating new standards. This new form of design when coordinated by efficient governance strategies can guarantee successful leverage of the innovation and knowledge creation made possible by the data infrastructure." (Suzuki, 2015)

The middle-out scope appears to adopt a broader focus in involving partners/actors from technology providers to community groups, as well as openness and flexibility to choosing the suited solutions. For instance, Stockholm's Royal Seaport case, this focus led to consistent and integrated city service delivery that comprises several sectors such as healthcare, waste management, community energy services, and telecommunications. In addition, seeking middle-out options allow city governments to consider longer time-spans in implementing and assessing the result of smart practices for new districts that require flexible and agile strategies in response to changes in technology applications.

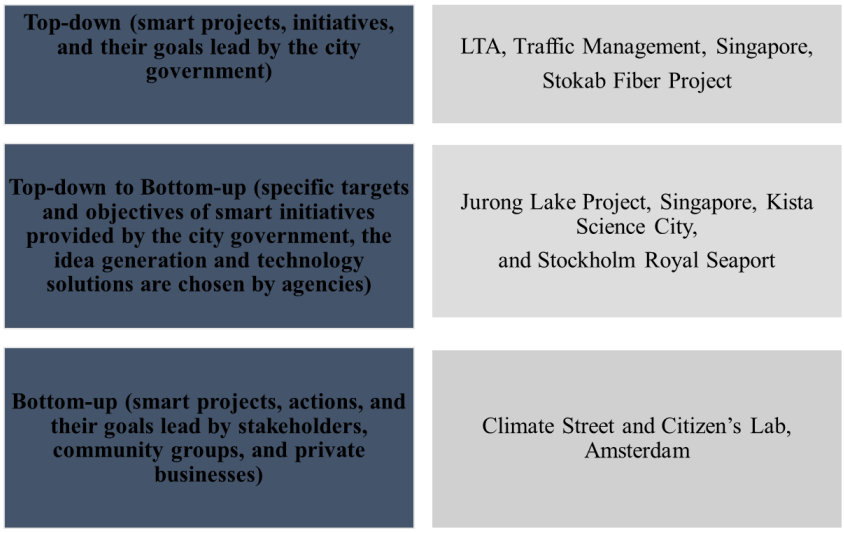

Figure 4-5 Different type of Approaches taken by initiatives (projects/ agencies), compiled by Author

Smart city approach necessitates the holistic demonstration of social and human capitals to create potentials for its stakeholders to look for more extensive socio-economic and environmental benefits. In the cases, each city embarked their smart practices with the attention to capital costs, return on investment (ROI[13]) models, and resource assessment/risk analysis of smart initiatives. Due to the nature of each city agency and its funding structures, some cases directly funded by a city government and some others provided human resources and government funds to assist their smart practices.

Due to the nature of the project (from a small-pilot to large-scale ones), the initiative may upscale and monetize smart offers to their clients (elements of test-bedding and prototyping) in various forms. Similarly, some projects can be funded by the private sector with some level of partnership with the government. For example, in Singapore, agencies like Infocomm, have a more facilitative role in terms of investment in human resources, to mobilize and organize partners and stakeholders with technology providers (Centre for Liveable Cities Singapore, n.d.). According to iNation report, the Jurong district project has been funded around $100 million (from 2015 to 2020), "as part of the Research Innovation Enterprise 2020 Plan" for the extension of urban informatics infrastructures and green housing development programs (Centre for Liveable Cities Singapore, n.d.). This strategic support could further expand Singapore's dominance in ICT and provide financial pathways for the commercialization of the projects and promotion of the entrepreneurial ecosystem in the region. (Centre for Liveable Cities Singapore, n.d.)

'Amsterdam AIM' fortifies its human resources to create collaborative platforms (Sanserverino et al., 2017), as it is important for securing funds and implementation of the project, the city thus relied on private funding resources, positioned itself as a partner rather than a financial provider. For instance, in the Citizen's Lab project with a budget of around $5 million, the company financed around half of the funding from private firms. As ASC reported, some of larger focused initiatives like Smart Work Center (Lee & Hancock, 2012) funded through public-private partnerships (PPPs), while other small-community focused

[13] Return on Investment (ROI) is a *"performance measure used to evaluate the efficiency of an investment on a particular case...ROI measure the amount of return on a investment relative to the investment's cost."* source: https://www.investopedia.com/terms/r/returnoninvestment.asp

project which required less initial capital like Citizen's lab supported through local enterprises. ("creation of new partnerships, ASC," n.d.).

For the RSP project in Stockholm, the estimated price tag was about $3.2 million, around two-thirds of the budget supported by "Swedish Governmental Agency and Vinnova" (Hollands, 2015), and "Swedish Energy Agency" for supplying intelligent infrastructures. The remaining funding (around a third) came from the participating vendors like "Grow Smarter" and "Stockholm Resilience Center" (Hollands, 2015) which had a decisive role in managing and test-bedding of the pilot projects in the district.

Another pertinent point in smart city financing is undertaking ROI and business models within the scope of the smart project. Since an initiative requires large scale investment, the justification cost by the city agency can be quite complex (Sing et al., 2014). Due to the limited scope of this research, further examination could analyze the details of city financial schemes and the level of investment and also the interaction between policy-making, city objectives, and smart initiatives. Further investigation can also compare cities' objectives towards fulfilling smart resilient goals (such as carbon-free transportation, net-zero residential complexes, flood warning infrastructures, etc.) against their willingness to invest for smart options that require an adequate level of funding and resources.

For newly launched projects, cost-benefit analysis (CBA) is typically carried out to clarify the budget for an initiative (BIS, 2013). Like consideration of negative externalities (such as economic cost resulting from newly launched E-bikes or EVs/hybrid car projects) and also many of the pilot projects in small scale cannot be readily assessed for typical ROI or CBA methods until they reached an optimal stage of their practice (BIS, 2013). In terms of creating self-supportive funding, the sale of data/information or actual urban services like web-services, city dashboards/APIs, or municipality apps can be a valuable source of investment (Eggers & Skowron, 2018). For example, sale of data may act as a viable source of revenue for cities (such as Amsterdam's City SDK Portal). Embracing open data policies can promote transparency and effectiveness of the initiative, as reliable utilization of free data could bring innovation and ensure fast city services (Sanserverino et al., 2017).

In conjunction with partnership activities with 'Swedish ICT' and 'Swedish Energy Agency', the approach engaged community inputs as evaluation feedback tools and data

collection (Hollands, 2015). In this value, the Stockholm approach seems to have a more holistic agenda in promoting community support, as well as attracting private funders. Some of the smart practices in Singapore technology hub have taken the "middle-out approach" (Ching & Ferreira, 2015) (like Jurong District Project) creating prototyping solutions and providing a collaborative framework to engage research institutions and asses the effectiveness of offered services. On the other hand, the bottom-up approach on small-scale practices shaped the smart innovation and entrepreneurial activities, which, in return, foster economic viability in the city (through boosting local capacities among shareholders) and stimulate start-ups to consider community services in a bigger scale.

Community-focused initiatives usually do not require substantial investment and resources to establish (Breuer et al., 2014) and typically involve the citizen's participation in their core practice. While it tends to be a bit chaotic in nature, a bottom-up approach has more flexibility, starting from small and local initiatives around citizens and embrace openness and divergence (Rodríguez-Bolívar, 2015). These values attributed to positive impacts on the regional scale, but also may have a conflict with the dynamism of economic growth and objective of urban planners in generic terms.

Smart initiatives in Amsterdam, taking on an open platform to create partnership and collaboration units, regardless of the scale of the project (such as 'Waag society' and 'Citizen Lab'). Combined with the city's smart goals, this versatility seems to be an advantage for a city to fully implement its potential to handle several types of initiatives (whether location-based or community-focused). These small/local-based initiatives act as pilot platforms raise awareness and acceptance in the transition towards knowledge-city (Angelidou, 2014). They created shared and encoded spaces that interaction and co-creation can take place. Still, these practices need to be allocated as a part of their city's strategic plans to anticipate synergies and shortcomings among other projects (Angelidou, 2014).

New methods need to be applied in the core part of the smart initiatives such as a clear set of rules for using/analyzing the data, a well-functioning administrative component and mutual form of citizen engagement (NLC's Center for City, 2017). That is to say, there a variety of steps to develop smart solutions, but not every answer or idea leads to meaningful

contribution. As it discussed having open data venues and platforms for sharing it, can encourage innovation and provide cities to manage future ICT-generated data-driven models (DuPuis NStahl E, 2016; NLC's Center for City, 2017), but these exclusive practices do not necessarily include the requisite analytical tools to qualify as smart city projects (DuPuis NStahl E, 2016). The initiative's aims should be integrative and multi-dimensional across several domains, which allows more elaborative examination of its goals to establish smartness.

As mentioned earlier, the term of the 'city as a platform' and 'urban living labs' can further elaborate on the underlying values of social and human capitals, such as the visible efforts of Kista Science City and Royal Seaport (Stockholm), and Green Living lab and Climate Street (Amsterdam). These sustainable innovations within the context of green labs/gardens and interactive architectures aptly manifested through interdisciplinary practices that emphasis on the strategic use of space for creating a dynamic urban living which (social) creation and (economic) growth are valued and highlighted ("Approach - AKKA Architects," n.d.). The interaction architecture in such practices goes beyond the static design process and unreferenced/rigid forms and fully contribute to making spaces that aligned with the understanding between citizens (user of smart applications) and designers of smart ecosystem, and somehow support the interaction of the user and his\her environment based on the knowledge-based engagement of inhabitants, visitors, and landscape designers.

Furthermore, These urban living spots and public spaces somehow created a gate and shared communities that value co-creation, innovation, and knowledge-sharing in a variety of scales and configurations. Also the underlying motives behinds these visions could explain that Amsterdam's and Stockholm's smart efforts mostly fall into this category in which their city administrative visions and governance models can denote that the shared and inclusive spaces are more valued rather than isolated, exclusive commercial zones.

Seemingly, due to single-tier government structure in Singapore and dedication of Infocom and IDA for the pervasive growth of ICT technologies may direct the planning perspective of the smart nation into more elite and technocrat forms of society in which the discussion of smartness is limited in technology-enabled environments (like smart

infrastructures/utilities for water and energy management). However, the promising master plans for the Jurong Lake district and attributions for smart living (e-healthcare and Aging Singapore projects) and smart community (mixed-used public spaces, eco-parks, and bio-regions) represented acceptable points for reaching inclusive and equitable approaches of intelligent and smart planning even through government-owned infrastructures.

Creating infrastructures and services that appropriately serve the needs of both communities and markets have been laid out in the fabric of smart city ecosystem in which the dialogue of co-creation and shared environment can be attributed to the planning/design processes (the same connotation that referred to the soft domain). Part of this dialogue starts with the understanding of the smart oriented design within and between urban places like plazas, streets, public spaces, and living districts (example of Amsterdam Climate Street, Green living gardens, and Stockholm's Royal Seaport district) where the element of smartness (shared workspaces, smart shopping, and green spaces) fully procured in the initiation and interoperability of smart applications across city districts. Another factor that elaborately discussed is the automation and optimization of smart devices and ICTs into city sub-systems (energy, transportation, water utilities) to support the objectives of a smart city.

The intelligently designed places like innovation cluster zones and urban digital marketplaces could be the highlighting patterns of technology-enabled public spaces and districts that offer tangible benefits of ICT integration in urban ecosystems (such as Stockholm's Stokab network). Through thoughtful and planned orientation in using and extending IT services into design processes, the operative capacities of novel IT systems are better captured in the physical contexts of a city. Indeed, more attachment to physical part (or hard domain) of smart ICTs with the concern for shared and inclusive space design further support the community needs and provide an ability to ensure more revenue and venture capitals for design actors, city agencies, and municipalities to initiate their smart projects/initiatives. Figure 4-6, summarizes the remaining notes and values of the projects in the examined cities.

Smart city case	ICT and Technology	Social capital focus	Entrepreneurship efforts	(data) security and privacy	Local-based strategies	Explicit strategic frameworks
Singapore smart city	Data management tools (cloud computing, business analytics, GIS,…) Data models (for using in finance, healthcare, tourism, transportation)	Enhancing public services, smart education and training, digital inclusion, knowledge-based community works	ICT-augmented training, learning, financial incentives for local-businesses, multinational companies	ICT security masterplan 2015	Developed as an international city, following national/governmental agendas	Development of ICT infrastructure and workforce, digital media, manufacturing and logistics, e-government
Amsterdam smart city	Data models and applications (for public participation, inclusive decision-making, city governance) Tools and metrics (broadband connections, smart meters and sensors)	Initiatives for public awareness, digital inclusion, transparency and civic innovation, mixed-used commercials	Business showcasing and incubation, knowledge-transfer, local-startup upscaling, local-business intensive areas	General focus	Emphasizing on social and environmental values, culture and community	General themes of mobility, living, society,.. Pilot projects, local based projects, open data, civic labs
Stockholm smart city	Data management tools (fiber-network, broadband service,) Data models (for using in tourism, social care, energy/water, waste,…)	Enhancing public services, environmental friendly communities, mixed-used commercials	High-end infrastructure, knowledge-transfer, local-business intensive areas	General focus	Emphasizing on long-term vision, environmentally-focused programs	Fully-connected city, green ICTs, efficient public transportation, open data

Figure 4-6 Pertinent points and valued efforts in smart projects, divided by the examined cities (compiled by Author)_main sources mentioned in the previous chapters

CHAPTER FIVE

5 CONCLUSION

5.1 Set of Recommendations and Implications

In the contemporary trend of city design, smart city paradigm has an opportunity to propose and come up with novel solutions against current urban challenges. Through creating eco-friendly approaches and enhancing city capacities in response to climate change and environmental issues, smart cities may ensure a promising roadmap for future developments. Smartness in a holistic view is the proper use of data and information generated from city services, social communication networks, and urban statistics (Dainow, 2017). It also supports the citizens by providing pragmatic services and platforms that encourage them to have roles in local policymaking and design development strategies (Rodríguez-Bolívar, 2015). Following the examination of the case studies, this chapter provides a set of potential comments and recommendations for implementing smart strategies based on the themes and values presented in the second and fourth chapters. Admittedly, the provided notes are a non-exhaustive and are provided to give a hint of further research within and beyond this field.

- *Integrate ICT systems/modules across city departments*

Cities need to combine ICT modules and integrate intelligent services in their governance and planning streams to facilitate the workflow and ensuring accurate results in public

services. These efforts will require the involvement of an individual city agency with the IT sector (or a technology firm), in which the cross-department collaboration could be examined/tested. These practices are more common in multi-department cooperation projects (BIS, 2013) as the case of 'Smart Nation' in Singapore. Aside from temporary projects, this coordination needs to be maintained for long-term planning scenarios (IBM Industry Solutions, 2013). As such, the outcomes of the projects (like urban energy transition) could be integrated with the transportation sector to assist automated predictions and scenario-making.

Through identifying the functions and connections amongst urban-systems, cities could accompany data-integration, citizen-behavior, and agency-structures into thoughtful responses (Ching & Ferreira, 2015). Also, cities can identify informing services, through re-organization in departmental levels to incorporate IT platforms (Diego Giron, 2018). It may establish new attributions for information management (Manville et al., 2017) and spatial and temporal data processes, and combine all of the outcomes to multi-disciplinary roles in several public domains.

- *Establish learning streams and feedback mechanisms for knowledge sharing*

As examined, one of the traits of smart cities is to initiate knowledge-groups and sharing experiences through mutual channels like international symposiums, civic workshops, learning events, and collaborative consortiums (Committee on Information Technology, 2015) to apply and implement the best-fitted strategies for their initiatives/firms. Similarly, the creation of feedback portals allows the instant assessment of the initiative's outcomes and link the initiative to other processes that broader in scopes and time-scales. For instance, in Amsterdam's Citizen Lab ("City of Amsterdam," n.d.), the feedbacks of community members had a positive impact on local energy policies and extended the primary and secondary benefits to environmental monitoring services and business modeling strategies. Also, the ease of data collection appears to provide more valued findings for cities to invest in smart initiatives even without a particular roadmap for a specific action. The current challenges in cities are not solely technical but socio-political. Cities need to consider how the pervasive usage of data will influence their governance

and policy-related tasks in the city administrative processes, and how to use data and legit information effectively for reaching maximum output.

- *Creating urban innovation groups and think-tank networks*

As seen in the "Climate Street and Citizen lab" (Amsterdam), and "Kista Science City" (Stockholm) projects, the citizen-oriented platforms, facilitated partnership streams and supported sustainability values for implementing smart goals. By taking an independent form of hierarchical structures (Regional Publications, 2014), these agencies can perform and exercise more freedom in applying solutions beyond the limitations of individual members. Also, this form of 'bird-eye scope' put them in a well-positioned status to identify opportunities and innovative solutions for cross-agency coordination and integration of viable resources.

Moreover, the engagement of the community members in both cities expanded potential resources (such as urban community energy and water planning projects), providing desired results in city-service delivery. For instance, through 'Open Data Streams', which give the potential to utilize data-driven models and crowd-sourced analytics in cities, the initiatives could further link the environmental-assessment tools with residents' inputs/feedbacks. Aside from the main generators of smart practices (municipalities, city agencies, technology firms), the social groups and innovative start-ups can provide shortcut into finding agile solutions and seek more effective outcomes. It seems evident that in the examined cases, research institutions have not considered as primary actors. Yet, the city departments can provide opportunities to both research organizations and civic groups to support the creating evaluation metrics/performance dashboards for the satisfactory outcomes for their groups.

One the open data side of the practice, architects of the smart ecosystem can enrich the value of their design platform from the data generated/obtained from businesses and ICT enterprises, via utilizing a full spectrum of data set composing demography, environmental performance, banking & finance, and municipal services. From that, the architects and designers can create city data in which digital marketplaces/spaces and design blueprints could be extended for monetization and outsourcing. Instead of taking mono-dimensional design blueprint perspective of the development of smart city services, these cooperative

groups with the aid of city councils and tech companies could offer tangible values on the architectural side via implementing user-driven and responsive layouts for the smart city even in a small scale like the case of Climate Street and Slussen historical district (as an example in the Slussen district employing data information embedded in installed IT devices and electric sensors across the city square and main streets provided valuable information about the status of the lighting conditions and the transportation flows in the nighttime to better design the lighting modules). Thus they could have a much more presence to shape urban life through empowering civic users and reconnecting urban links during planning charrettes and design sessions.

Likewise, another valuable benefit of having open-data portals and interactive city dashboards is to provide transparency and immersive insights for designers and city planners to detect and understand spatio-temporal patterns and citizens-behavioral habits (in terms of daily activities: shopping, using public transportation, spending time in public spaces, using specific commuting routes, etc.) to address the dynamic changes of such factors in their design schemes and proposals. For instance, the 3D-enabled city environment in 'Virtual Singapore' platform can facilitate the task of architects and city designers in developing design blueprints and identify the potential (and proper) building topologies according to the microclimate, topography, water bodies, and existing transportation systems of a region or a neighborhood.

- *Providing tangible roles for architects and city designers in the core of smartness*

With the current metamorphic changes of data-driven services in architecture and urban design practices, smart cities indeed shaped the language of inclusion and interaction through public participation and community development in such a way that ICTs and related automation applications frame the design topologies whether through providing inclusive and participatory planning strategies (such as Kista Science/Royal Seaport in Stockholm and Climate Street Project in Amsterdam) or creating environmental and ecological-conscious design platforms (the case of Green Labs in Amsterdam and Eco-districts in Jurong lake island, Singapore). Thus the context of the organization of space and the role of interactive modules could further be linked with the idea of the 'wired city'

and ‘all presence environment’ that somehow delineate on the current scheme of smart environment and community sub-dimensions (see Table2-2, 2nd Chapter).

However, the presence of ICTs and IT tools further add to the complexity and interpretation of public spaces, which required synergic progress and collective efforts between city agencies and urban designers to take advantage of data-enabled decision making and digitized planning models (like the case of Virtual Singapore and Sensible Urban Labs) to further expand the impact and the acceptance of such tools in design and planning sectors.

In regards to data ownership and data control many smart initiatives and community design startups rely on the vast amount of data pools generated from devices and sensors (from traffic lights, urban water pipes, PV/solar panels, etc..), especially in the urban interaction design venue, there are a couple of concerns to mention: who has the ownership to these urban generated datasets? And should the accessibility of such urban data models/info be granted to the public (users of smart services)? Do they (user/citizens) necessarily have enough skills to make changes and modifications to the data? (the case of using feedback loops/user inputs for urban water & energy projects in Amsterdam and Stockholm). To what extent and in which ways the designers and architects of smart ecosystems need to give functionality over datasets for users? Alternatively, do citizens and public users need to have a role in the organization or the operation of the data/info for the project? Given the specialty of the field, the formal design blueprints and digital data models may not be apprehensible to the public’s eye, resulting in an inadequate understanding of the smart design/service. So it is worthwhile to consider the ownership of the data among different actors of the smart projects.

On the social side of the practice, architects and designers need to consider the heterogeneity of urban communities, and socio-cultural values underpinned in the core of civic lifestyle. The societal values should have a more deterministic direction in the design of the public spaces and how smart yet resilience the cities will become. The sole-proprietary technology pockets installed in city squares, streets, and shops do not fully assimilate to the core of the city services. To understand the cultural equity and social inclusion both in terms of designing the places and offering the hi-tech services, the city designers and architects can have more powerful interventions — such values implemented

in zoning codes, design charrettes, master planning objectives. From the planning vantage, these tools and guidelines can be practiced in designing of more responsive/interactive civic buildings, public plazas, public arts, etc. to represent the visual and experimental manifestation of smart urban living.

Undoubtedly, the thinking paradigm of smart cities aggregated on the technology-laden values that controlled and monopolized by big technology companies and IT firms and still there is a limited room for the intervention by architects and city designers as leading armatures for the initiation/development of smart solutions. Yet again, the collective efforts among the leading actors, specifically on the supply side of the smart value chain (such as designing energy-conscious buildings/districts and intelligent public hubs) can propose meaningful impacts on the acceptance of novel ideas through reciprocal cooperation between planners and designers.

- *Identify the suited approaches to set-up a partnership*

Additionally, in structuring partnership, the city needs to consider multiple business models and procedures to procure the partnership goals aptly (DuPuis NStahl E, 2016). A few concerns can be issued; how much resources do city agencies need to allocate in their own in the absence of technology firms? How can city departments (and their specified services) be adopted in response to a new platform and services associated with for bringing in smart technologies? Are the start-ups presenting new disruptive applications that aimed for substantial (monetary) profits? How can IT firms directly provide backbone infrastructure for intelligent services? How can the new foundations be implanted/transferred in the existing city departments? Also, how partnership frameworks could be oriented toward more-inclusive participation models to foster local entrepreneurship/markets in test-bedding and experimenting of smart urban projects? Furthermore, future works could examine the best methods that motivate citizen participation in decision-making process via indirect communication platforms like web-based services and also to what extent the citizen input is necessary before the initiation of a project.

- *Pursuing long-term and broader perspectives*

In the examined case studies, a track of defined long-term vision can be noticed. For example, in the "Amsterdam's City SDK" and "Open Stockholm", the initiatives have taken open data approach that encourages on long-term benefits of seeking innovation, improving community partnerships and offering inclusive civic services ("City of Amsterdam," n.d.; "Smart and Connected City," 2017). Hence, a long-term plan towards more extensive benefits is vital for stakeholders in implementing their smart initiatives that require cities to objectify and define their short, medium, and long-term targets both in investing and policy-making efforts (Angelidou, 2017). Notably, in Singapore's JLD area, the implementation of smart facilities required more time compared to less complicated initiatives like web-based or mobile apps.

Aiming for longer agenda-setting could also mobilize entrepreneurial ecosystem and marketing within and across city districts, which proved to provide an auxiliary momentum in smart initiatives (such as Stockholm's Science City, and Singapore's IES). With the (growing) presence of living labs and think-tank groups and deep attention on cultural and spatial proximities among these centers, advocating on entrepreneurship activities could further facilitate the supply of new urban markets and services (Richter et al., 2015). Due to the duration and scope of municipal services, governmental support may not assure a long-term dedication to projects. Thus, fostering entrepreneurial ecosystems through start-ups and dedicated individuals, ensuring extensive commitment to the local/neighborhood issues, as well as providing a stronger sense of social contribution.

- *Expect disruptions and challenges in terms of data privacy and information security*

By considering the fast growth of service-automation and instrumentation of intelligent systems in standard urban services, cities need to find elements of (disaster) risk and disruptions (both natural or human-made) in their CBA, especially for critical city-functions such as emergency response management and real-time waste management services (BIS, 2013). For example, initiatives that directly involve in smart grids and service utilities could be susceptible to sudden changes arising from cyber-security attacks/disruptions considering their dependency on constant network support. Thus, an investment in redundancy and protection should be a part of their primary aims.

Utilization of information and analytical models for managing and regulating urban systems/functions promotes a "technocratic mode of governance" (Kitchin, 2014b) (as it presumes itself into a state of rationality) that all aspects of a city can be monitored, measured, and treated as technical problems (Bücker, 2016; Kitchin, 2014b). Additionally, a technocratic form of governance fails to take into account the broader effects of socio-cultural and political states that shapes the city life. They do not address the 'root problems,' but rather an oversimplification of issues (Bücker, 2016).

While cyber-security and data safety procedures do not fall into the responsibility of architects and urban designers, they do permanently interact with the constant flow of information and data-models in projects and building. White a dominant rise of IoT, remote project modeling, and cloud-based building information modeling (CBBIM[14]) in design studio workflows and architectural firms, the generated information (whether from 3D models and CAD datasets) are prone to hacks, leaks, and changes (the apparent examples are Virtual Singapore Platform and Sensible Design Labs in Amsterdam). In these current scenarios, there could be a set of data policies and cybersecurity standards for architectural firms and real state agencies to share and transfer the data safely. Also, to ensure the client' data security, utilizing blockchain technology and network security across design firms, city agencies, and clients are essential. Thus, more research and empirical studies can be done to evaluate the feasibility of big data, IoT and BIM integration within/across architectural firms to reveal the adaptability of current design workflows with such smart technologies for more efficient service delivery.

Similarly, the socio-political considerations associated with the one-sided investment on the technological portion (ICT systems) of the smart cities is another factor. For instance, the blatant proliferation of artificial intelligence within a city environment may lead to propriety actions on city-wide systems that are running proprietary software and platforms. The danger is the creation of "corporate path dependency" (Kitchin, 2014b), which can marginalize a part of the citizens who cannot respond, and adapt to rapid changes and leading to the "digital divide and urban inequality" among educated, skilled-inhabitants,

[14] one prime example of such technology and design software company is Autodesk, which is the leader of CAD software, some cloud platforms like BIM 360, ICT tracker fully implemented in cloud platforms to provide real fast data accessibility for construction managers, designers and civil engineers, https://www.architectmagazine.com/practice/how-to-secure-your-firm-from-cyberattacks_o

uneducated users (Hollands, 2015). In order to reach the full potential among our urban communities, smartness should take a deep-rooted practice of innovation, collaboration, and learning among the active users and indeed governmental reforms and organizational changes need to re-align and adopt as a part of this movement. Smart city planning can contribute to trust, transparency and performative governance services within our urban communities. The below diagram (Figure 5-1) gives an overview of key points throughout the discussion with some reference to the design projects (small/large scale) and completed smart services for a better association of smart service integration/implementation in a variety of urban design and architectural practices.

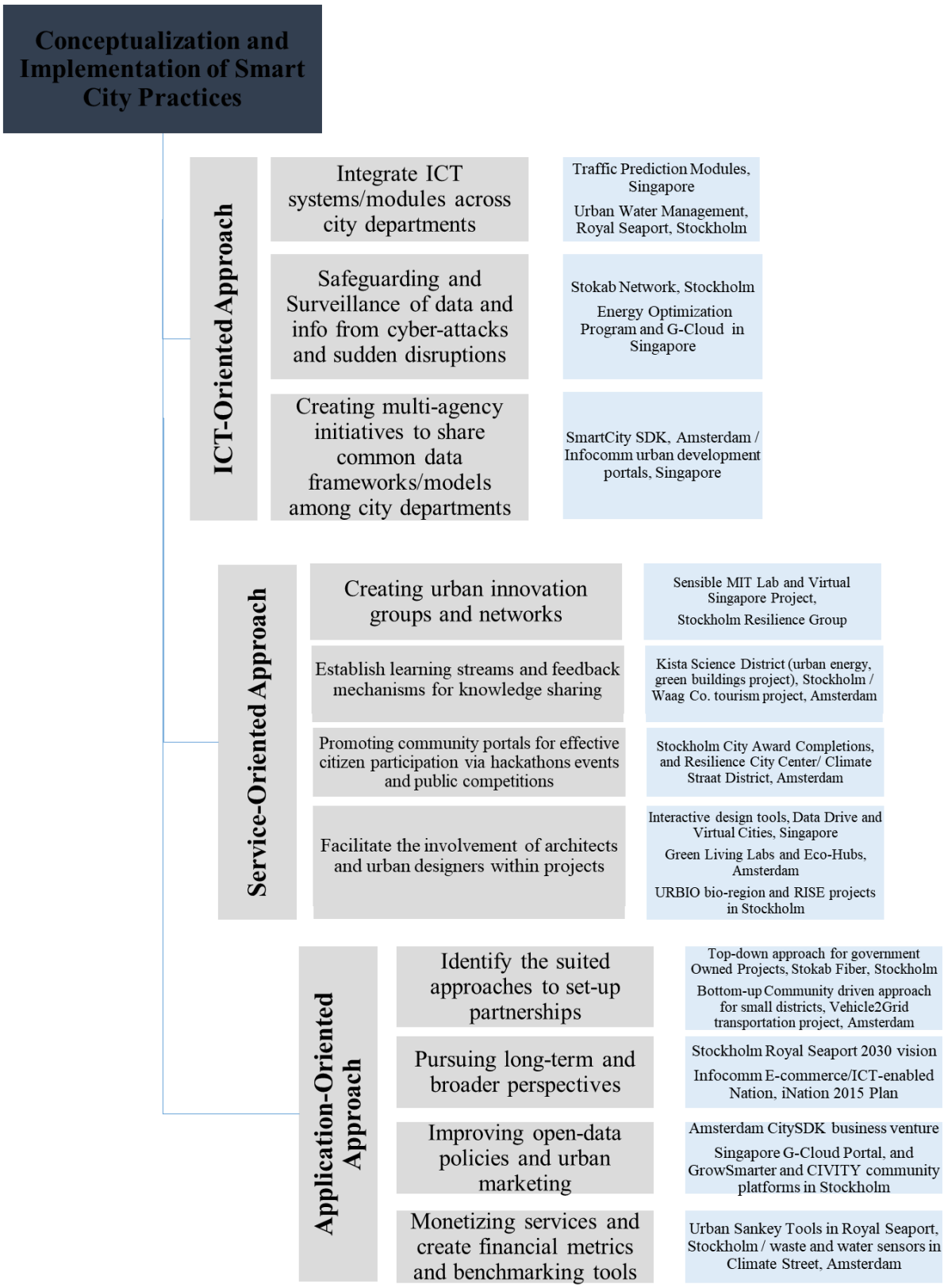

Figure 5-1 Summary of the keynotes in the initiation of smart city projects with the elaboration of smart services and urban design projects (provided by Author)

5.2 Potential Roadmaps for Smart Cities

Considering the recommendations above, conceptualization and implementations of smartness (through smart initiatives) in cities can take different pathways. For instance, a city that embraces a top-down development needs to align its existing infrastructures with rigid partnership models (in line with IT-firms) to maximize the application of multi-scale ICT functions in city services. Here ICT acts as a basis for mobilizing and identifying ideas. In this platform, networked systems are only enablers for the enhancement of economic development and e-governance aims. Thereby, that city can combine information modules, incorporating multi-scale benchmarking tools/mechanisms, and pursuing a long-term vision to reach maximum benefits. Additionally, the city is not restricted to a traditional top-down approach, which constrains the scope to set of specific issues; instead, through taking an inclusive approach, the city could achieve higher outcomes (such as creating cross-silo efforts via the integration of ICT or seeking partnership platforms for knowledge sharing).

Another city may adopt a bottom-up approach in its smart practice. That city can focus on improving partnership frameworks, communication networks, and collaborative channels via grass-roots community-driven initiatives as well as generating robust partnerships with technology firms, architects, urban designers, and research institutions. One limitation though is the fragility of the entrepreneurial and local activities (i.e., community start-ups, small initiatives) that may not sustain the long-term frameworks and cannot provide competitive expertise for city firms. In these cases, the middle-out platform appears to ensure openness and flexibility to address issues and reap stronger partnership solutions with technology firms. This approach tends to more inclusive for several types of smart initiatives ranging from small-scale community-driven practices to large-scale infrastructure projects. Hence, by taking a combination of these approaches, a city can invest in developing deep technological methods with the aid of businesses and industries, and concurrently improve its collaborative partnership with city start-ups, community groups, and academic units.

There is a consensus that smart cities are the outcomes of ICT integration and applications in urban development and planning. The pervasive technological support, such as the

internet of things, big data, and cloud computing[15] promote the capability of urban service delivery and management. With the new generation of information technology in urban communities, the core goal of being smart is to maximize the service delivery, information sharing, and use of various civic infrastructures and public spaces that ultimately offer intelligent services for residents, initiatives, and industries.

Following the ever-increasing attention to smart technologies, smart cities, in particular, this thesis aimed to elaborate on smart city notion and related applications of initiatives in the urban context, as well as exploring the ever-growing attention to smart cities with a focus on smart initiatives and applications. A general analysis of the term and a more profound examination of the city cases have clarified the traits and principles of smart cities. Undoubtedly, the use, implementation, and integration of ICTs have shaped the landscape of smart cities, yet, such a technocratic focus may lead to the limited scope in investing of IT infrastructures and optimization of city services, without considering the inherent values of social and human capitals.

Being smart does not solely refer to harnessing ICTs in the city functions; instead, it is more about the conclusive and holistic vision that addresses socio-economic and environmental objectives of a city, a district, and a community. It needs to have a framework that involves a transparent agenda setting within and among city departments/agencies and technology actors, and forming rich partnership platforms with involved stakeholders. It also needs to emphasize the rational decision-making choices that match the city's capabilities with its goals, as well as improving feedback mechanisms, evaluation scorecards/benchmarking tools and learning avenues to remain responsive during the process. Admittedly, any model or attempt to define a smart city will be useful if it is integrative and multi-dimensional across multiple urban domains, which allows more elaborative examination of initiatives/firms and their goals.

Likewise, in order to achieve the maximum potential of inclusion and innovation, smart citizens scope need to be a part of the intelligent urban living ecosystems. As such

[15] "the use of a network of remote servers and share pools of computer system resources, hosted on the internet to manage and process data away from a local server or personal computer", source: https://www.cimconlighting.com/what-is-a-smart-city

municipalities, architects, urban designers, and civic groups can be the active players in shaping the architecture of smart applications for the transition to creative and self-aware cities. To that end, pursuing novel design paradigms toward re-use, co-creation, and open services trigger social acceptance for using technology and foster the applicability of smart solutions like semantic-web, crowd-sourcing, and IoT in daily activities of citizens. Every town or city is boasting its own identity through manifestations of its history, culture, and customs.

As mentioned before, the catchphrases like sensor city, ubiquities and sense city as passive formula/solution for the prosperity of city life could also aggravate the socio-political conditions of urban life such as corporate surveillance and social segregation, and the omission of individual privacy. Turning into an active smart ecosystem which triggers ground-up movements and inclusive smart projects could better reflect the value of technology in civic life. Tomorrow's cities are shaped by the practice and efforts of smart city architects of today who can design/plan smart ecosystems that have a capacity for better integration and association of ICT modules (such as IoT, BIMCloud, Big data) and city design systems (augmented/virtual reality, user interfaces, mobile apps,..) through co-creative and shared spatial platforms. The genuine model of smartness within the heart of the urban design starts with the proper DNA and vessels of responsive ICT architecture that orients toward knowledge-based efforts by community members and city designers, through inclusive efforts.

Alternatively, it seems to be a valuable point of interest for cities to respond to the contemporary challenges of urban design and planning such as capacity development with the resilient focus, climate change mitigation/adaptation strategies, and urban ecosystem assessment as an integral part of their smart vision. Furthermore, strategic/developmental plans and urban regulatory policies should be included within decision-making platforms, and thus, smart solutions shall not be considered as a separate trajectory in the planning stream of urban areas and city districts. The integration of creative practices in the core of the method can be invaluable roadmap to reach sustainable development goals.

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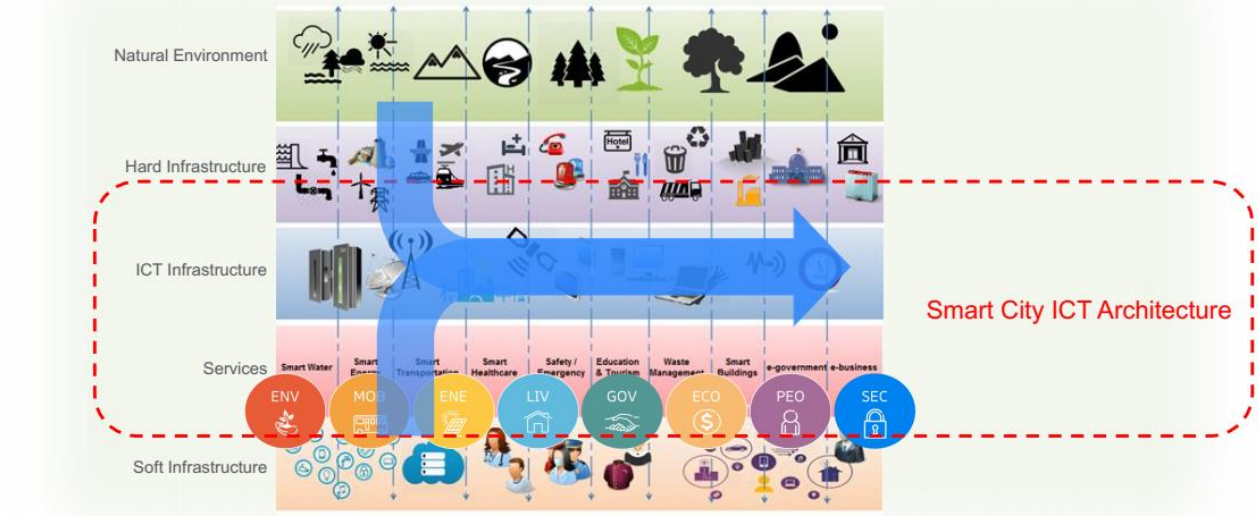
APPENDIX

2_A



Multi-layer Architecture of smart city, layered conceptual services, Source: https://techinsight.com.vn/language/en/pioneering-technologies-in-urban-traffic-management-and-operations/

2_B

Component of ICT, Source: https://searchcio.techtarget.com/definition/ICT-information-and-communications-technology-or-technologies

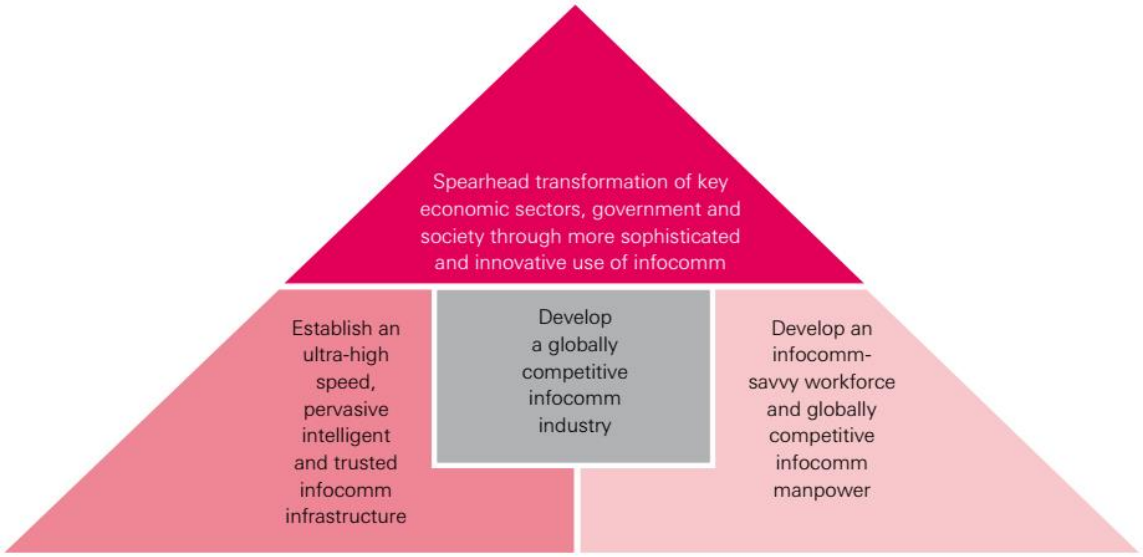
While there are varied definitions around the ICTs, Rouse aptly refers the terms as "all devices, networking components, applications and systems that combined allow people and organizations (i.e., businesses, nonprofit agencies, governments and criminal enterprises) to interact in the digital world." (Rouse, 2017)

ICT components encompass a multitude of automation units and IT systems, including "both the internet-enabled sphere as well as the mobile one powered by wireless networks. It also includes antiquated technologies, such as landline telephones, radio and television broadcast…" (Rouse, 2017)

For more info, refer to this source.

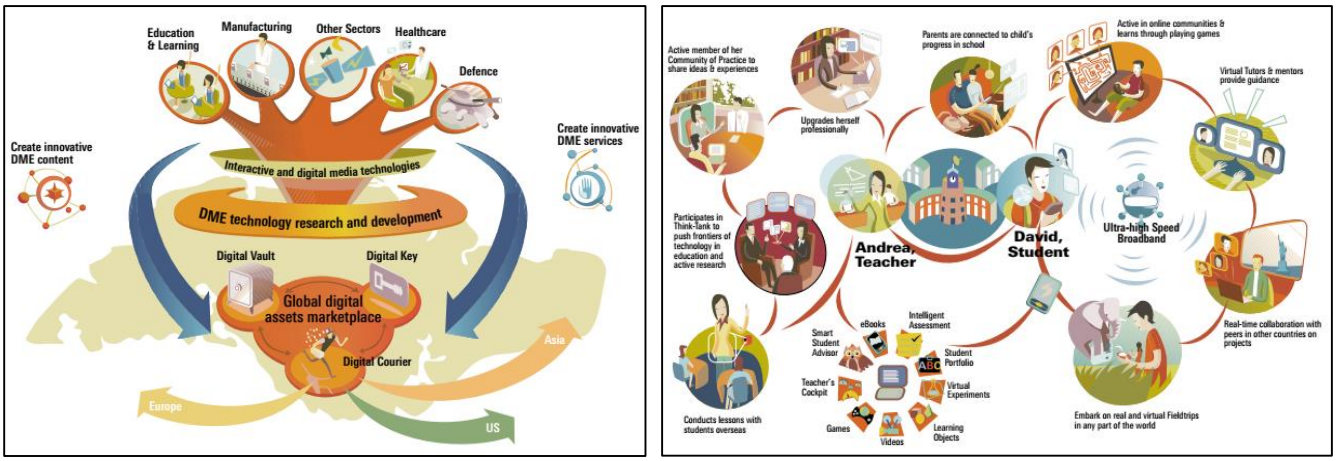
https://searchcio.techtarget.com/definition/ICT-information-and-communications-technology-or-technologies

3_A



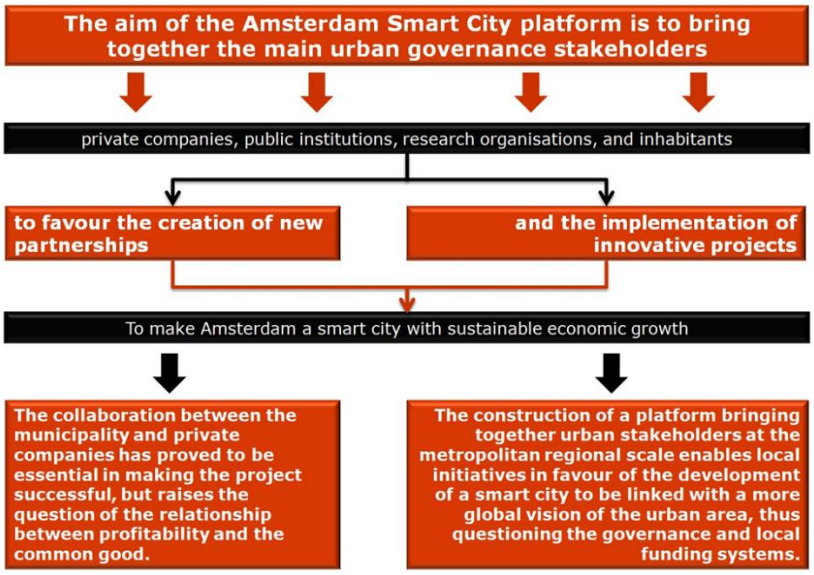
iN2015 Strategic Thrusts, The triangular focus manifests four strategic thrusts for Singapore to innovate, integrate and internalize smart vision through Infocomm
from "An Intelligent Nation, a Global City, powered by Infocomm" (iN2015 Steering Committee, 2015)

3_A`



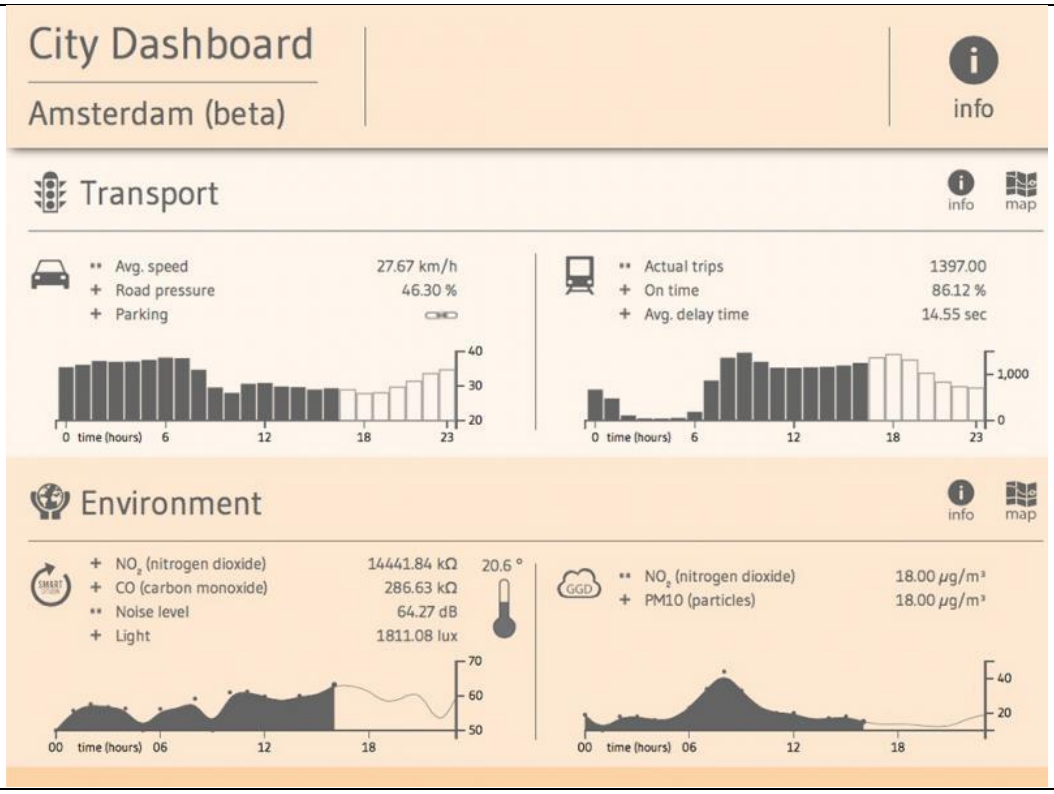
iN2015 infographic of innovative creation for digital media (left), education and learning (right)
Please zoom in!
from (iN2015 Steering Committee, 2015)

3_B



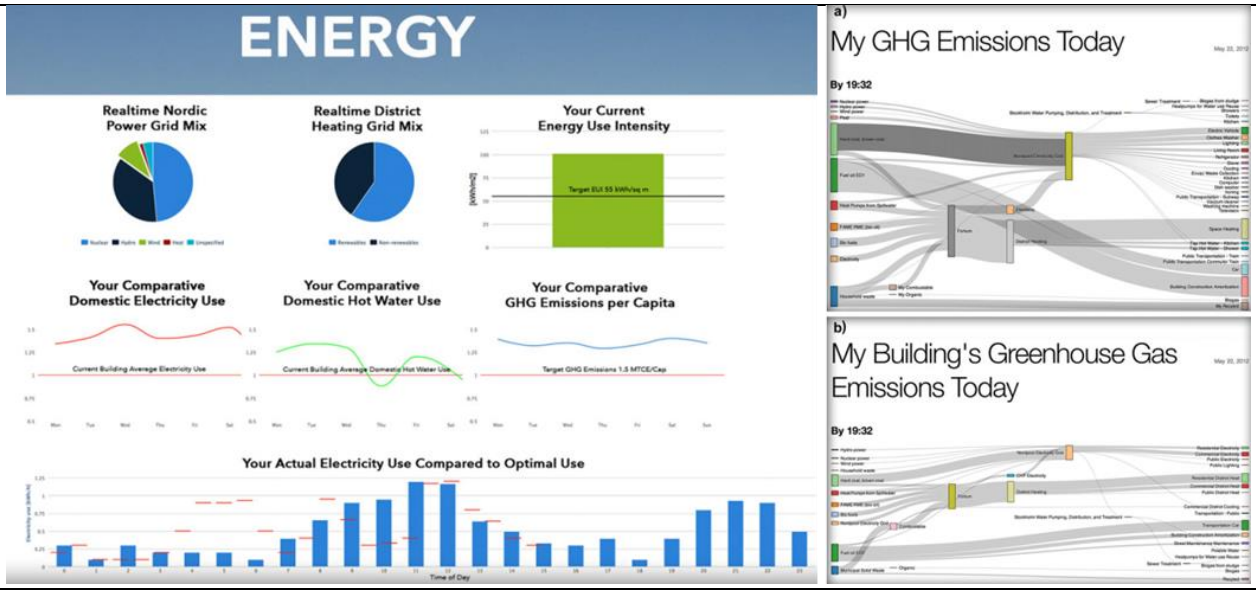
Amsterdam Smart City Collaborative Platform, the diagram adopted from (Eggers & Skowron, 2018)

4_A



Amsterdam Smart Dashboard adopted from http://citydashboard.waag.org/

4_B



Smart City SRS dashboard (energy diagrams) and notification charts adopted from (Shahrokni et al., 2015)