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# A proposed assessment scheme for smart sustainable urban development

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# A Proposed Assessment Scheme for Smart Sustainable Urban Development

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## DEDICATION

This thesis is heartily dedicated to my Parents, Professor Dr. ABDELFATTAH ELFIKY, Previous Head of Haydraulics Department, Ain Shams University, Cairo, Egypt and my mother, AMIRA MOHAMED FATTOUH, who had always supported me in whatever path I took.

May the Almighty God richly bless you both.

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I Thank god for all his blessings, and the protection and ability he has given me to fulfill my dream and accomplish this Study.

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## ABSTRACT

The twenty-first century belongs to the cities. For the first time in history, more than 50% of the world's population now lives in a city and the urban population is expected to double by 2050. The opportunities created by new technologies challenge the way in which we conceive our cities, how we plan, design and construct them and how we will live in them. The current large gap between smart city and sustainable city frameworks implies that there is a need for developing their frameworks further or re-defining the smart sustainable city concept, which is relatively new and can be seen as a successor of information city, digital city and sustainable city. Furthermore, rating standards like LEED and (GPRS) do not cover all the topics behind the Smart Sustainable City Concept.

The aim of this study is to conduct and perform qualitative and comparative analysis of International Standards and case studies, to provide a foundation for developing a framework for the planning of a Smart Sustainable City based on rigorous criteria and sub-criteria. This framework, can be used to assess the smart sustainable urban development of the new administrative capital of Egypt. The criteria have been selected according to international standards via ISO37120 and the Focus Group of Smart Sustainable Cities of International Telecommunication Union (ITU-T FGSSC), as a base for the framework. The framework developed in this study is more oriented towards achieving aspects of urban life at the design and planning stage versus other models existing in the literature that are more oriented towards progress in International Communication Technology (ICT) as a dimension by itself and as means to transform already built cities to smart cities. The proposed study is intended to build up and complement key dimensions that were developed by ITU-TFGSSC, by adding sub-dimensions and key indicators filling this gap in research.

The outcome of this study could be used to generate a framework and develop recommendations that has been tailored for urban planners, owners, operators and occupiers, to successfully and cost effectively adopt smart sustainable solutions as they plan, design, construct, and manage future cities. City assessment tools can be used as support for decision making in urban development as they provide assessment methodologies for cities to show the progress towards defined targets.


[1]Smart Sustainable Cities KeyDimension Sub-Dimensions

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## LIST OF SYMBOLOS

| | |
|---|---|
| **ICT** | Information Communication Technology |
| **LEED** | Leadership in Energy and Environmental Design |
| **GPRS** | Green Pyramids Rating System |
| **UN** | United Nation |
| **YADW** | Yale Urban Design Workshop |
| **ITU-T-T-FGSSC** | Focus group for smart sustainable cities of International Telecommunication Union |
| **SSC** | Smart Sustainable City |
| **BRT** | Bus Rapid Transit |
| **AV** | Autonomous vehicle |
| **A2X** | Vehicles for all |
| **BIM** | Building Information Technology |
| **KPI** | Key Performance Indicators |
| **SNDGG** | Smart Nation and Digital Group |
| **IoT** | Internet of Things |
| **AI** | Artificial Intelegence |
| **NBN** | Nationwide Broadband Network |
| **HetNet** | Hetrogeneous Network |
| **(CBD);** | The Convention on Biological Diversity |
| **(ECLAC)** | The Economic Commission for Latin America and the Caribbean |
| **(FAO)** | The Food and Agriculture Organization |

| | |
|---|---|
| **(ITU)** | The International Telecommunication Union |
| **(UNESCO)** | The Regional Bureau for Sciences in Latin America and the Caribbean of the United Nations Educational, Scientific and Cultural Organization |
| **(UNDP)** | The United Nations Development Programme |
| **(UNECA)** | The United Nations Economic Commission for Africa |
| **(UNECE)** | The United Nations Economic Commission for Europe |
| **(UN-Women)** | The United Nations Entity for Gender Equality and the Empowerment of Women |
| **(UN Environment)** | The United Nations Environment Programme |
| **(UNEP-FI)** | The United Nations Environment Programme Finance Initiative |
| **(UNFCCC)** | The United Nations Framework Convention on Climate Change |
| **(UN-Habitat)** | The United Nations Human Settlements Programme |
| **(UNIDO)** | The United Nations Industrial Development Organization |
| **(UNU-EGOV)** | The United Nations University-Operating Unit on Policy-Driven Electronic Governance |
| **COP 21** | The United Nation Climate Change Conference in Paris |

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# CHAPTER 1: IINTRODUCTION

## 1.1. Background

The Twenty First Century belongs to the cities. Cities were ruled first by empires followed by nation states. All urban activities, Social, Economic and Environmental services take place in cities, this has led to a global wave of urban development projects. The Smart sustainable City is an essential part of this wave, and will be explained further in this study. In the Twenty First Century, many cities are transforming from sustainability assessment to smart city . The main objective of smart cities is to use advancement and applications in Information Communication Technology (ICT) to achieve sustainability. Hence, we recommend the use of a more applicable terminology “smart sustainable cities” (instead of “smart cities”), as suggested also by Kramers, Höjer, Lövehagen, and Wangel (2014). The smart sustainable city terminology will ensure that sustainability and urban aspects are not over looked in smart city development.

The smart Sustainable city concept has been presented in many International and national conferences lately. In 2016 the United Nation Conference that was held in Quito to discuss urban sustainability during the Habitat III conference, presented a new policy direction that has emerged. That is that smart cities are being introduced as a new mean to achieve sustainability and urban resilience. This terminology has been recently adopted also by some European (UNECE) and international (ITU, 2016) standardization bodies..

## 1.2. Problem Statement

The opportunities created by new technologies challenge the way in which we conceive our cities, how we plan, design and construct them and how we will live in them. The current large gap between smart city and sustainable city frameworks implies that there is a need for developing their frameworks further or re-defining the smart sustainable city concept, which is relatively new and can be seen as a successor of information city, digital city and sustainable city. Furthermore, rating standards like Leader in Energy and Environment Design (LEED) and the Green Pyramids Rating System (GPRS) do not cover all the topics behind the Smart Sustainable City Concept. The framework developed in this study is more oriented towards achieving aspects of urban life at the design and planning stage versus other models

existing in the literature that are more oriented towards progress in International Communication Technology (ICT) as a dimension by itself and as means to transform already built cities to smart cities. The proposed study is intended to build up and complement key dimensions that were developed by ITU-TFGSSC, by adding sub-dimensions and key indicators filling this gap in research.

### 1.3. Research objective

The aim of this study is to conduct and perform qualitative and comparative analysis of International Standards and case studies, to provide a foundation for developing a framework for the planning of a Smart Sustainable City based on rigorous criteria and sub-criteria. This framework could be used to assess the smart sustainable urban development of the new administrative capital of Egypt, one of the most ambitious and important urban development projects at present in Egypt. The criteria have been selected according to international standards via ISO37120 and the Focus Group of Smart Sustainable Cities of International Telecommunication Union (ITU-T FGSSC), as a base for the framework. The framework developed in this study is more oriented towards achieving aspects of urban life at the design and planning stage versus other models existing in the literature that are more oriented towards progress in International Communication Technology (ICT) as a dimension by itself and as means to transform already built cities to smart cities. The proposed study is intended to build up and complement key dimensions that were developed by ITU-TFGSSC, which developed the key dimensions without developing sub-dimensions and key indicators for the model generated, creating a gap in research. The proposed study has developed sub-dimensions and key indicators to fill this gap. Collective methodology for core indicators has been presented. Debates about environmental challenges are often hindered by lack of problem definition, uncertainty about the nature of these challenges, and ill-defined solutions. Gathering data into the recommended proposed framework helps to resolve these difficulties.

**Potential users of recommendations:**

- City Officials to understand the advancement in ICT and how its applications can be used in making cities smarter and more sustainable. This can help City officials and municipal administrations develop strategies to achieve progress.
- City residents and non-profit organizations – enabling them to understand the development and progress of SSC.
- Help city service providers, operation and maintenance organizations to share information and applications of ICT for better performance and advancement of services in the city.
- Evaluation and ranking agencies, including academia – supporting them in selection of relevant key performance indicators for assessing the contribution from ICT in the development of SSC.

**To sum up, the goals of the study are:**

- Understand how the Smart Sustainable City Concept can be seen as the driving engine in achieving urban development aspects and in defining the Smart Sustainable City Concept.
- Develop a framework to assess and prioritize Smart Sustainable City Development.
- Develop guidelines and recommendations to be implemented and applied for management of Smart City Projects.

### 1.4. Methodology of research.

A qualitative and comparative analysis methodology has been applied through a systematic and in depth review of the literature, aimed at sustainable development of smart cities which examines the terms, 'smart city' and 'sustainability**.** Furthermore**,** the criteria have been selected according to official documents of international standards via ISO37120 and the International Telecommunication Union (ITU),which builds on the importance of standardization in facilitating knowledge sharing and achieving the appropriate guidelines for implementation. Quite often, smart city activities are undertaken in a fragmented manner by governmental agencies working in isolation without using global standards.The collective methodology for core indicator has been explained. In addition,comparative analysis of case studies and direct interviews have been

conducted in collaboration with the Yale Urban Design Workshop (YADW). This practice-based multi-disciplinary environment has allowed the interaction with other students and faculty for assessment of each criterion bringing together the natural behavioral and social sciences with engineering to articulate a holistic approach that is essential for our study.

# CHAPTER 2: LITERATURE REVIEW

The Smart City and Sustainable city are being used interchangeably throughout. To better understand the relation between the two concepts, we will review the definitions of “sustainable”, “smart” and “cities” are and then proceed to discuss them.

## 2.1. “Sustainable” concept

The term “sustainable” refers to a concept that is based in social construction to refer to the level of development. and thus we need to define the term “sustainable development” or “sustainability” accordingly using a deductive approach. A more adequate definition for sustainable development would be the one developed by Brundtland (WCED, 1987) as a foundation for of a guideline for the SSC concept. Brundtland states that,

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

This definition adeptly highlights the significance of both the needs of the present and their effects on the needs of the future generations. It is important to note that the needs of the poor should be taken into special consideration. However this definition is not suitable for use on a country level due to its global nature, yet the Swedish government has overcome this issue by defining its “generational goal”, which states,

“the overall goal of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden’s borders” (Gabrys, 2014).

This addition or ones that hold similar connotation would in turn be more suitable when applied on the country and city levels.

## 2.2. “Smart” concept

There is a large debate over the proper use of the word “smart” as researchers in the field prefer its normative use in reference to a desired outcome as is the case with the concept of sustainability (Allwinkle, 2011), rather than what is considered an

instrumental connotation referring to a system in which ICT has a large role. However when the roots of the term in the context of cities is investigated, it yields a better understanding to its current use, such as the case of marketing when it is used to denote a focus on user perspective (Klein, 2008). Accordingly when considering the meaning of the term from in the urban planning field, the smartness in smart growth is treated as a normative claim and ideological dimension, thus being smarter entails strategic directions. All levels of Governments and public agencies, are adopting the smart concepts distinguish their new policies, strategies, and programs for targeting sustainable development, sound economic growth, and better quality of life for their citizens (Centre on Governance, 2003).

This can also be said for technological applications and the adoption of the term as they propagated into the commercial application of intelligent-acting products and services, artificial intelligence, and thinking machines (Moser, 2001). When it comes to the context of technology, the term "smartness" refers to an automatically computable process like self-configuration, self-healing, self-protection, and self-optimization (Spangler et. al, 2010). A wide array of constructions such as smart homes, smart buildings, along with larger ones like airports, hospitals or university campuses are equipped with a multitude of mobile terminals and embedded devices as well as connected sensors and actuators all contributing to the smart element of the construction(Klein and Kaefer, 2008). For larger communities the extension of a smart ecosystem is made from the personal context to this wider such as in the case of entire cities as well. (Yovanof and Hazapis, 2009).

### 2.3. Cities concept

A "City" is a place where people live that is larger or more important than a town. It is an area where many people live and work (Webster, 2015). In this research the scope of the terms smart and sustainable will be that of cities. It is used to indicate the types of human structures and environments where smart solutions for sustainable development may exist. However since the existence of cities is taken for granted , they cannot be seen as instrumental such as the case with the term "smart" and thus the focus of this research is shifted to what could be made to make cities more sustainable instead of simply the adequacy of cities for sustainable development.

Due to the enormous impact on the environment and the monumental role socially and economically that cities play, they are considered key elements for the future (Mori and Christodoulou, 2012). With cities being by far the largest points for consumptions of the world's resources, and their contributions should be considered both economically and conversely environmentally. In several cases the promotion of sustainability has been through the promotion of natural capital stocks. However since humans can be regarded as the central actor in the relativity on a universal scale Recent interpretations have promoted a more anthropocentric approach so that cities would respond to people's needs through sustainable solutions in social and economic regards (Turcu, 2013).

The introduction of various definitions for the concept at hand by the international community, governments, Academia and private sector has resulted from blending these three different terms which lead to the creation of an abundant literature on smart cities' definitions with the sustainability component being explicitly mentioned in the some definitions while not in others. Fearing that the sustainability aspect in smart cities might be overlooked, the ITU Telecommunication Focus Group on Smart Sustainable Cities (ITU-T FGSSC) conceptualized the new term "Smart Sustainable Cities", which could be taken as a version of smart cities that include some of the core features of eco-cities/sustainable cities.

### 2.4. Smart Sustainable Cities definition

(Giffinger at al., 2007) smart should be considered as performing in a forward-looking way and focuses on issues such as awareness, flexibility, transformability, synergy, individuality, self-decisiveness, and strategic behavior, yet some definitions (e.g. Harrison et al's study) note that a smart city is an instrumented, interconnected, and intelligent city as well. However, the Natural Resources Defense Council defines smarter in the urban context as more efficient, sustainable, equitable, and livable. (Toppeta, 2010) emphasizes the improvement in sustainability and livability. (Washburn et. al, 2010) Consider a smart city as an amalgamation of smart computing technologies applied to infrastructure at critical components and a service noting that smart computing reflects an updated version of collectively integrated hardware, software, and network technologies that provide IT systems and real-time awareness of the real World, advanced analytics and actions that optimize business processes.

The lack of a standardized definition can be attributed to the fact that the term is applied to two different types of "domains". The first is in "hard" domains where a crucial role is played by technologies in the functions of the systems. These domains include but are not limited to buildings, energy grids, natural resources and mobility (Neirotti et al, 2014). The second is in "soft domains" such as, education, culture, policy innovations, social inclusion, and government, where the application of ICT is not usually critical. The existence of terms that are similar to "smart cities" namely digital, intelligent, virtual, ubiquitous, information, learning and knowledge city, has had a multiplying effect to the confusion. These terms refer to more specific and less inclusive levels of a city, so that the concepts of smart cities often include them (Caragliu et al., 2011; Deakin and Al Waer, 2011; Townsend, 2013).

To determine what would be a comprehensive and inclusive definition of a smart sustainable city from the perspective of the work being undertaken by the Focus Group on Smart Sustainable Cities (FG-SSC) the ITU performed an in-depth analysis in an attempt to standardize the definition of SSC, while taking the above discussants opinions into consideration. To identify what makes a Smart Sustainable City, around 120 of definitions were analyzed. Using the conducted analysis as its foundation, a comprehensive definition was presented on the basis of the below mentioned specifications for a SSC (ITU, 2014):

- Improve the quality of life of its citizens.
- Ensure tangible economic growth such as higher standards of living and employment opportunities for its citizens.
- Improve the well-being of its citizens including medical care, welfare, physical safety and education.
- Establish an environmentally responsible and sustainable approach which "meets the needs of today without sacrificing the needs of future generations".
- Streamline the physical infrastructure based services such as transportation (mobility), water, utilities (energy), telecommunications, and manufacturing sectors.
- Reinforce prevention and handling functionality for natural and man-made disasters including the ability to address the impacts of climate change.

- Provide an effective and well-balanced regulatory, compliance and governance mechanisms with appropriate and equitable policies and processes in a standardized manner.

In October 2015, ITU and the United Nations Economic Commission for Europe (UNECE) developed the following definition for smart sustainable cities Figure


Figure (1): Definition of smart sustainable cities (FGSSC, October 2015)

This definition is the definition that will be adopted in this study It provides a standardized basis for any assessment model and it is comprehensive and adopted at the global level, hence it is the most suitable to be used in this study.

### 2.5. Smart Sustainable Cities dimensions

The Dimensions of SSC have several variations depending on the literature portraying them, and it is not relevant for all actors and perspectives similarly. For instance, from the angle of sustainability, researchers argue for the irrelevance of smart technologies being used given the solutions implemented lead to an increase in sustainability and accordingly the concept of a sustainable city would be sufficient. On another hand, from the perspective of ICT industry, researchers and practitioners argue that the industry works with smart solutions regardless of their impact on sustainability since it is not one of their priorities, which allows the concept of the smart city to be appropriate and sufficient for them. However since this focusses on the country's objectives towards SSCs, these differences in opinions become valid. Meaning that the city's context impacts its implementation for SSCs. Given now that the context of each city would give rise to a variance in these definitions it is imperative to identify the dimensions of SSC. After careful revision of the dimensions of SCs and SSCs differences and commonalities that mentioning would be of value

appears. (Giffinger et al, 2007) identified four components of a smart city which are: industry, education, participation, and technical infrastructure. This list of four components has since been expanded by the Centre of Regional Science at the Vienna University of Technology which has identified six main components (Giffinger and Gudrun, 2010). These components are as follows: Smart economy, Smart mobility, Smart environment, Smart people, Smart living and Smart governance. These components relied on the theories of urban growth and development namely: regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of society members, with "quality of life" being an addition that is worth highlighting. The definition that a smart sustainable city is a city, which increases the quality of life of its citizens is highlighted in this component (Giffinger et al., 2007) (ITU-T, 2014). However, since this dimension should be a general goal that is sought to be achieved through all the other dimensions many researchers argue that it should not be considered as a separate dimension.

To identify the components of a SSC, different stands are taken by researchers, during the creation of a smart city. Dirks and Keeling, (2009) Emphasize the significance of the organic integration of a city's various systems. The systems of cities include but are not limited to transportation, energy, education, health care, buildings, physical infrastructure, food, water and security. It is the belief that due to the dense environment in cities, that no system operates in seclusion that lead Researchers to advocate for this integrated view of a city. (Kanter and Litow, 2009) repeat this view and confirm that it is insufficient to introcduce intelligence in each subsystem of a city on one-to-one basis in the creation of a smart city, as cities should be dealt with holistically. However, to clarify this concept many other researchers have separated it into several features and dimensions. (Lombardi et al., 2012) associated the six components presented in (Giffinger et al, 2007) with different aspects of urban life. When an economy has a large presence of industries in the field of ICT, or employing ICT in the production line, the term smart economy is presented. Building the ICT capacities of citizens is dubbed smart education. The use of ICT to achieve democracy and transparency is dubbed smart governance. he use of ICT in modern transport technologies to improve urban traffic is dubbed smart mobility refers to, Smart environment has been linked to harnessing ICT efficiently for achieving sustainability; and Smart living refers to the use of ICT for achieving a

secured and enhanced quality of life for citizens. For (Nam and Pardo, 2011), the central components of a smart city are the technology, the people (creativity, diversity, and education), and the institutions (governance and policy). Only when a boost in sustainable growth and an enhancement in the quality of life is achieved through investments in human and social capital, together with ICT infrastructures is a city really smart. Many other authors discussed the key dimensions of smart and sustainable cities. Table 1 provides a summary of the main dimensions discussed in the literature.

Table (1): Main Dimensions of a Smart Sustainable City (Al-Nasrawi et al,2015)

| Key dimensions of a smart city | Source |
|---|---|
| Economic (GDP, sector strength, international transactions, foreign investment) Human (talent, innovation, creativity, education) Social (traditions, habits, religions, families) Environmental (energy policies, waste and water management, landscape) Institutional (civic engagement, administrative authority, elections) | (Barrionuevo et al., 2012) |
| Management and organizations Technology Governance Policy context People and communities Economy Built infrastructure Natural environment | (AlAwadhi et al., 2102) |
| Technology Economic development Job growth Increased quality of life | (Eger , 2009) |
| Economy Mobility Environment People Governance | (Giffinger et al., 2007) |
| Human capital (e.g. skilled labor force) Infrastructural capital (e.g. high-tech communication facilities) social capital (e.g. intense and open network linkages) Entrepreneurial capital (e.g. creative and risk-taking business activities) | (Kourtit and Nijkamp, 2012) |
| IT education IT infrastructure IT economy Quality of life | (Mahizhnan, 1999) |
| Economic socio-political issues of the city Economic-technical-social issues of the environment Interconnection Instrumentation Integration Applications Innovations | (Nam and Pardo, 2011) |
| Quality of life Sustainable economic development Management of natural resources through participatory policies Convergence of economic, Social, and environmental goals | (Thuzar, 2011) |

The notion that the SSC entails more than simply the implementation of technologies and strategies aimed at meeting today's needs without compromising those of future generations was captured by the ITU, through its FGSSC. It is also

noted that SSC is about understanding the city itself: its identity and its goals, its stakeholders and their priorities, thus identifying the attributes that would tailor to the uniqueness of each city while enhancing its overall living quality and sustainability with the support of ICTs. The FGSSC identified six dimensions along with attributes. The six dimensions are: Economy, Mobility, Environment, Society, Quality of life and Governance.

Through thorough analysis of the SSC dimensions devised by the ITU-T FGSSC, we note that a map of the connections and relations between them is viable. The ITU-T FGSSC did not use the word “smart” in the name of the dimensions. It replaced the word “People” with “Society” and explicitly replaced “Living” with “Quality of Life”. As mentioned earlier, selected authors argue that Quality of Life should not be a dimension on its own believing that it is a crosscutting concern, regardless it is still important to place it at the core when assessing SSCs

Information Communication Technology plays a key role in SSCs, as they act as a digital platform that could be used to create an information and knowledge network. This is especially beneficial, in the aggregation of information and data, for the improvement of understanding and analysis of the functionality of the city, in terms of resource consumption, services, and lifestyles. This in turn would provide a reference for various stakeholders to take action and create policy directions that would eventually improve the quality of life for the citizens and the society as a whole. Nam and Pardo,( 2011) considered technology as a central dimension in a smart city, a consideration shared by many authors and practitioners in the field. This being said, another group of researchers including the ITU_T FGSSC do not consider technology as a dimension of the city, Yet we still attribute a high importance to the role of ICT in the establishment of SSC and rather look at it as the component that is at the core of SSC. Information Communication Technology plays a crucial role. It acts as the focal point responsible for managing and coordinating all the interactions between the different pillars and the infrastructure. It connects various everyday living services to public infrastructures, and thus plays a crucial role, It is the manager of the numerous components of the SSC which are required (IEEE SC, 2014).

### 2.6. Measurement models for Smart Sustainable Cities

Table (2) summarizes these models and sheds light on the main objectives of each model.

Table (2) : Selected measurement models for aspects of SSC (Al-Nasrawi et al,2015)

| Model | Managing Entity | Base Year | Objective |
|---|---|---|---|
| Digital Economy Ranking | Economist Intelligence Unit | 2000 | Assesses the quality of a country's ICT infrastructure and the ability of its consumers, businesses and governments to use ICT to their benefit. |
| Network Readiness Index | World Economic Forum | 2000 | Provides policymakers, business leaders, and concerned citizens with important observations in relation to the current market conditions and connectivity status across the globe. |
| E-government Development Index | United Nations Department of Economic and Social Affairs | 2002 | Measures the willingness and capacity of national administrations to use ICTs to deliver public services. |
| Global Competitiveness Index | World Economic Forum | 2005 | Focuses on the criticality of structural economic fundamentals for sustainable development. |
| Global Innovation Index | World Intellectual Property Organization (WIPO), Cornell University and INSEAD | 2007 | Provides a unique tool for refining innovation policies, creating an accurate picture on the role of science, technology and innovation in sustainable development, and assessing where more efforts are urgently needed in the area. |
| ICT Development Index | International Telecommunication Union | 2008 | Monitors the progress in ICT development in both developed and developing countries and the progress in relation to bridging the digital divide. |
| Green City Index | Economist Intelligence Unit | 2009 | Compares major cities in terms of their environmental performance and policies and assists in understanding the strengths and weaknesses of each city and their performance against peers |
| Better Life Index | Organization for Economic Co-operation and Development | 2010 | Monitors people's well-being and societal progress |
| Change Readiness Index | KPGM International Cooperative and Oxford Economics | 2010 | Shows the country's capability for managing change hypothesized to support sustained growth in the long-term. Change readiness is measured against three different categories namely: Social capabilities; Governance capabilities and Economic capabilities. |

A much more extensive list of models is available in the literature, from which the models overviewed in the previous section were selected due to their relevance to the topic and their coverage to aspects of the SSCs. Table 2 summarized the listed models and displays that the models focus, in wide-ranging degrees, on aspects related to the social and economic development of a country, its infrastructure and its environmental policies. They specifically took the national economic competitiveness status and the infrastructure in terms of network readiness and ICT developments into consideration. Some of the models focused on the ability to absorb ICT and use it for economic and social benefit in along with to the capacity of delivering e-government services by the national administrations through ICTs. With achieving a high quality of life for its citizens considered as the central objective of a SSC, the e-government's implementation is a prerequisite for this transformation towards SSC, whether the ICT acts an enabler for this transformation; these models could be used to partially assess the performance of SSCs according to the selected dimensions. Another set of models focused on the country's capability for managing change and its environmental performance and policies.

# CHAPTER 3: DESIGN AND PROCEDURES

## 3.1. Key dimensions of smart sustainable cities

Literature illustrates that there is a difference in the key dimensions, also mentioned as pillars, main axes or sections of a SSC. A comprehensive analysis of these dimensions was recently conducted by the focus group on SSCs of the ITU, which acts as the international platform for sharing knowledge and developing best practices of developing smart sustainable cities . The analysis led to setting the dimensions to six, namely: smart economy, smart people, smart governance, smart mobility, smart living and smart environment (ITU-T FG-SSC, 2014).

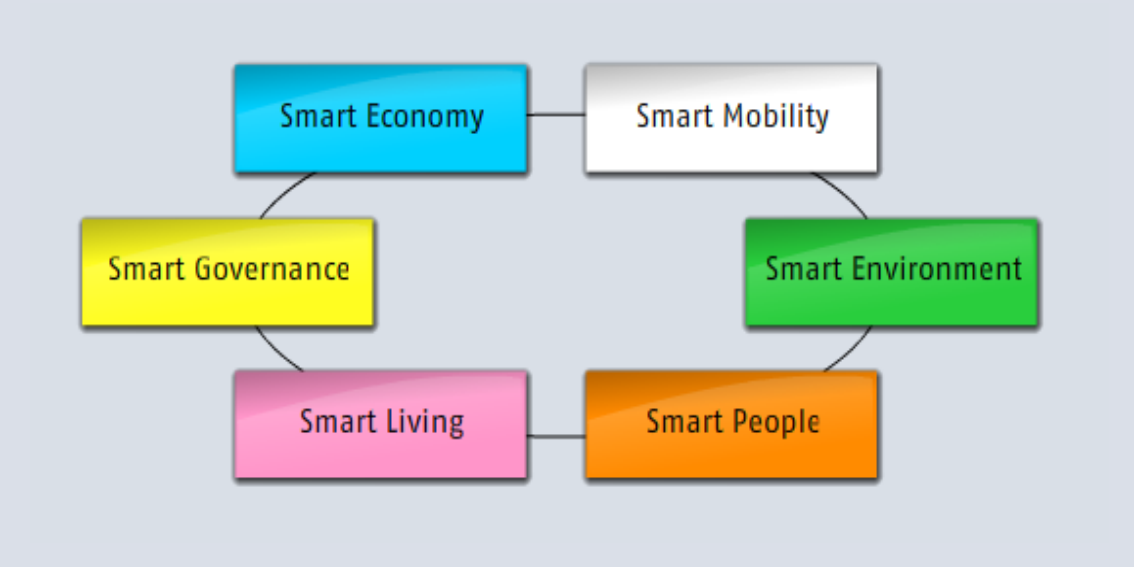


Figure (2): Key Dimensions of a Smart Sustainable City ( ITU-T FG-SSC, 2014)

A conceptual model for measuring smartness of a SSC has been developed (Al-Nasrawi et al,2015 ). Fig 2 The model captures the smartness measure of a particular SSC through observing the performance of a city along the six dimensions adopted by the ITU-T FGSSC as previously discussed.

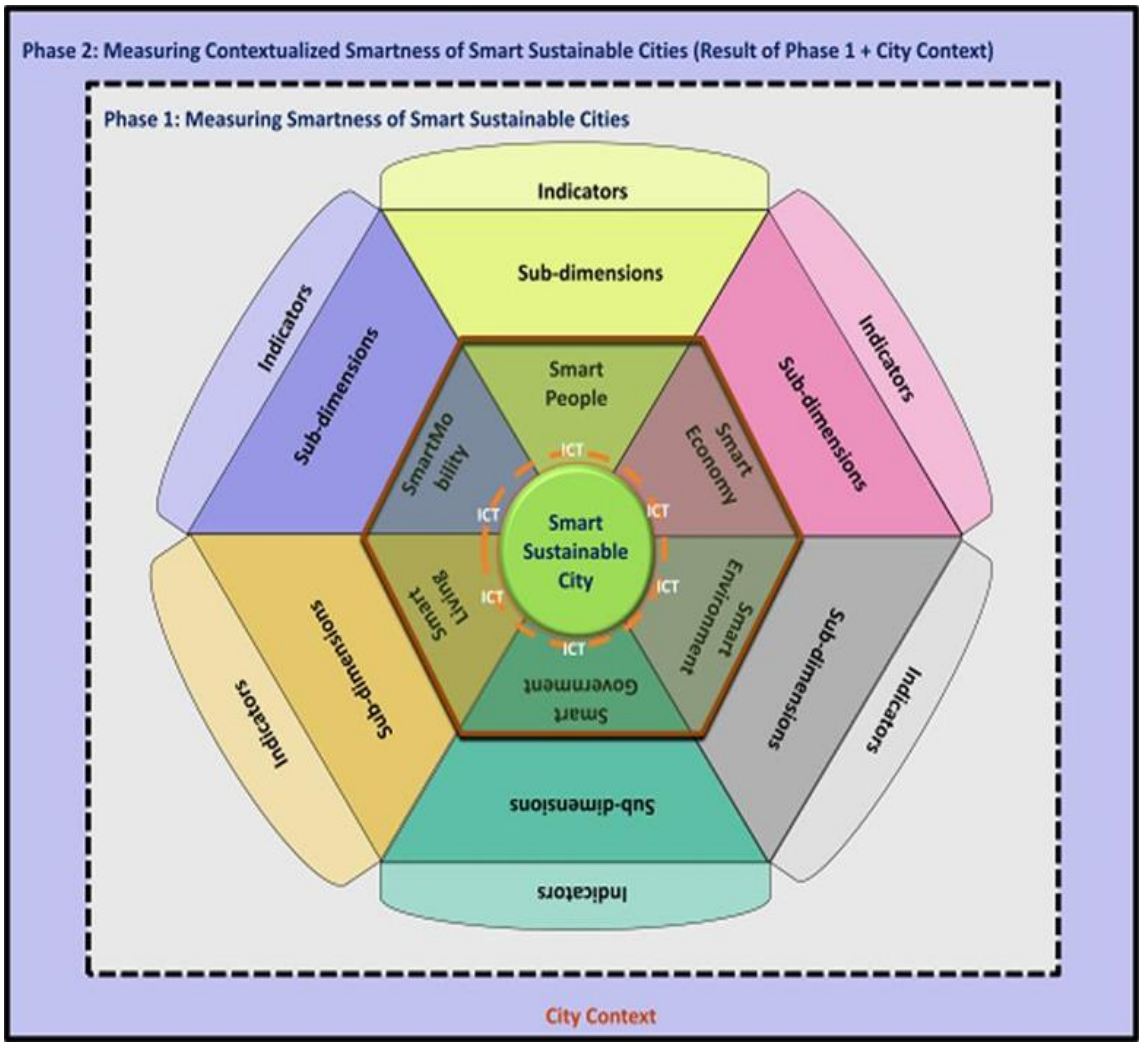


Figure (3) Key Dimensions of smart sustainable cities (Al-Nasrawi et al,2015)

### 3.2. Sub Dimensions of smart sustainable cities (Habitat-Master Planning Frame Work 2016) adopted in this study

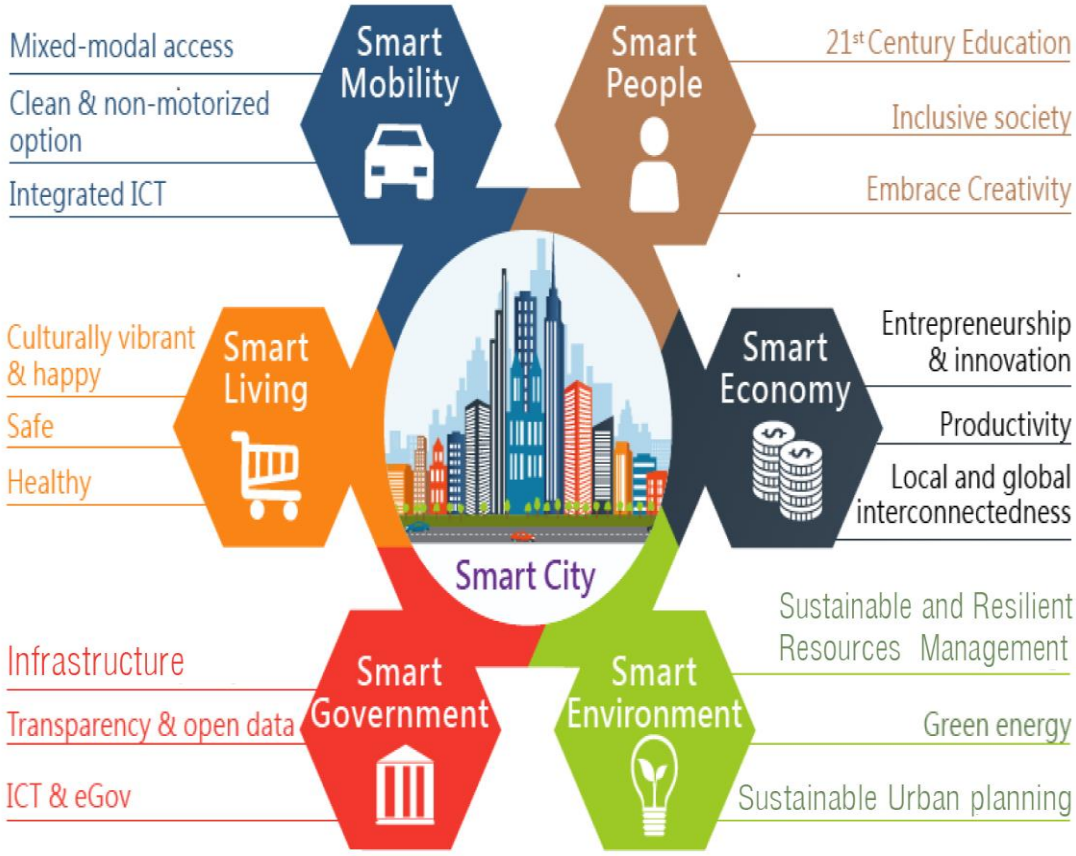


Figure (4): Sub-dimensions for Smart Sustainable Cities

https://www.urban.com.au/urban-industry/2015/06/23/smart-cities-habitat-master-planning-framework

Each dimension is divided into core sub dimensions that has been identified concretely through a set of indicators. In this study further research has been conducted to identify those key indicators. Figure 4 illustrates those sub dimensions and Tables (3,4,5,6,7and8) illustrate the Key Indicators for smart cities developed by the author and had been assessed with Yale University Urban Design Workshop, through interviews and panel discussions. The criteria have been selected according to official documents of international standards via ISO37120 and the Focus Group International Telecommunication Union (ITU-TFGSSC), the collective methodology for core indicators have been

explained in Appendix A. The key indicators and the collective methodology for each core indicator is linked by a reference number that is illustrated in both tables. In addition, direct interviews have been conducted in collaboration with the Yale Urban Design Workshop (YADW).

### 3.3 Key Indicators for smart cities Tables (3,4,5,6,7,and8)

**C:** Core indicators that were developed by ITU

**A:** Added indicators that were developed by the Author

Table (3): Key indicators for Smart Mobility (Developed by the Author)

| DIMENSIONS | SUBDIMENSIONS / KEY INDICATORS | | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| Smart Mobility (SM) | (SM.1) Multimode Transport Systems Accessible and integrated | (SM.1.1) Public Transportation | 1) Kilometres of annual high& low capacity public transport trips /100000 ITU-T | C | (SM.1.1.1) |
| | | | 2) Transportation mode share% of commuters using transport other than a vehicle ITU-T | C | (SM.1.1.2) |
| | | | 3) Central underground Metro stations to be connected to City | A | (SM.1.1.3) |
| | | | 4) Bus Rapid Transit BRT in addition to franchised buses by private sector (all using clean energy) | A | (SM.1.1.4) |
| | | | 5) New Railway development strategy and speed trains | A | (SM.1.1.5) |
| | | | 6) More carpooling and sharing activities with incentives like free parking and free gas(platform for carpooling) | A | (SM.1.1.6) |
| | | | 7) Freight Tunnel to separate private cars , public transportation traffic and freight traffic | A | (SM.1.1.7) |

| DIMENSIONS | SUBDIMENSIONS / KEY INDICATORS | | DEFINITION/ DESCRIPTION | TYPE | /REFRENCE |
|---|---|---|---|---|---|
| Smart Mobility (SM) | (SM.2) Information Communication Technology (ICT) Infrastructure | (SM.2.1) ICT and Internet of Things (IOT) | 1) No of Fixed Broadband Subscription/100000 population ISO37120/7.1 | C | (SM.2.1.1) |
| | | | 2) No of Wireless broadband Subscription/100000 population ISO37120/7.2 | C | (SM.2.1.2) |
| | | | 3) % of the city served by Wireless broadband Coverage 4G and 5G | C | (SM.2.1.3) |
| | | | 4) Availability of Wi Fi coverage in public areas | C | (SM.2.1.4) |
| | | (SM.2.2) Monitoring and Real Time Information Technology | 1) % of Dynamic public transport information available to the public in real time | C | (SM.2.2.1) |
| | | | 2) % of road intersections using adaptive traffic control for light signals or prioritization measures | C | (SM.2.2.2) |
| | | | 3) % of major streets monitored by ICT | C | (SM.2.2.3) |
| | | | 4) Real time for parking spaces available | A | (SM.2.2.4) |
| | | | 5) Metering and Sensors Coverage for services (Electricity, water, energy, waste) | A | (SM.2.2.5) |
| | | | 6) Build technology hubs and advance manufactory centres | A | (SM.2.2.6) |
| | | | 7) Develop a scalable data platform for smart city data sharing | A | (SM.2.2.7) |
| | (SM.3) Sustainable | (SM.3.1) Innovative and Safe | 1) % of total trips of public transport achieved with smart cards | A | (SM.3.1.1) |
| | | | 2) International Easy and Efficient Travel with Smart Airport | A | (SM.3.1.2) |

| DIMENSIONS | SUBDIMENSIONS / KEY INDICATORS | | DEFINITION/ DESCRIPTION | TYPE | /REFRENCE |
|---|---|---|---|---|---|
| | | | 3) Advancement of technology Vehicles vehicles for all (V2X )and Autonomous (AV) | **A** | **(SM.3.1.3)** |
| | | (SM.3.2) Non-motorized options | 1) % of bicycle paths for 100,000 ISO37120 /18.7 | C | (SM.3.2.1) |
| | | | 2) Promote walking through pedestrian finding and recommend walking routes | A | (SM.3.2.2) |
| | | | 3) Establish "bicycle-friendly" new towns with cycling tracks and bicycle parking facilities and applications. The puplic transpotation should complement the cycling tracks to | A | (SM.3.2.3) |

**Table (4): Key indicators for Smart Government** (by the Author)

| DIMENSIONS | SUBDIMENSIONS / KEYINDICATORS | | DEFINITION / DESCRIPTION | TYPE / REFRENCE | |
|---|---|---|---|---|---|
| Smart Government (SG) | (SG.1) Online Services | (SG.1.1) ICT aimed at improving access to information and building capacities | 1. e-governance Number of public services delivered through electronic means | C | (SG.1.1.1) |
| | | | 2. e-procurement Percentage of public sector procurement activities that are conducted electronically | C | (SG.1.1.2) |
| | | | 3. Unified access point for all government services on a single plat form | A | (SG.1.1.3) |
| | (SG.2) Infrastructure | (SG.2.1) Electricity | 1. Electricity Supply, Percentage of households with authorized access to electricity | C | (SG.2.1.1) |
| | | | 2. Electricity System Outage Time Average length of electrical interruptions | C | (SG.2.1.2) |
| | | | 3. Electricity System Outage Frequency, Average number of electrical interruptions per customer per year | C | (SG.2.1.3) |

| DIMENSIONS | SUBDIMENSIONS / KEYINDICATORS | | DEFINITION / DESCRIPTION | TYPE / REFRENCE | |
|---|---|---|---|---|---|
| | | (SG.2.2) Water and Sanitation | 1. Basic water supply Percentage of households with access to a basic water supply | C | (SG.2.2.1) |
| | | | 2. Potable Water Supply Percentage of households with a safely managed drinking water service | C | (SG.2.2.2) |
| | | | 3. Sanitation, Percentage of households with access to basic sanitation facilities | C | (SG.2.2.3) |
| | | (SG.2.3) Waste | 1. Solid waste collection | A | (SG.2.3.1) |
| | | (SG.2.4) Transportation | 1. See smart mobility Dimension | | (SG.2.4.1) |
| | | (SG.2.5) Sensors | 1. Sensors and meters coverage for monitoring services consumption | A | (SG.2.5.1) |
| Smart Government (SG) | (SG.3) Open Governance | (SG.3.1) Open Data | 1. Use central data management to assess growth and sustainability | A | (SG.3.1.1) |
| | | | 2. % of mobile applications available based on open data | A | (SG.3.1.2) |
| | | | 3. Privacy | A | (SG.3.1.3) |

| DIMENSIONS | SUBDIMENSIONS / KEYINDICATORS | | DEFINITION / DESCRIPTION | TYPE / REFRENCE | |
|---|---|---|---|---|---|
| | | | 4. Voters participation in last municipal election as a percentage of eligible voters | A | (SG.3.1.4) |

**Table (5): Key indicators for Smart Economy** (by the Author)

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| Smart Economy (SE) | (SE.1) Entrepreneurship and Innovation | (SE.1.1) R+ D | 1. % of GDP invested in Research and Development (R +D in private sector) | C | (SE.1.1.1) |
| | | (SE.1.2) Patents | 1. Number of Patents for 100000 population ISO 37120 5.7 | C | (SE.1.2.1) |
| | | (SE.1.3) Entrepreneur -ship | 1. Assessed value of total commercial and Industrial properties as a percentage of total assessed value of all properties | C | (SE.1.3.1) |
| | | | 2. Number of Businesses for 100000 population ISO 37120 5.6 | C | (SE.1.3.2) |
| | | | 3. Facilitate business licensing and registration to foster entrepreneurship in the city | A | (SE.1.3.2) |
| | | | 4. Develop economic plans and policies, identify and support the growth of strategic sectors, and provide services to domestic and international investors and businesses. | A | (SE.1.3.4) |
| | (SE.2) Productivity and Employment | (SE.2.1) Productivity | 1. Broad band internet connectivity /100 capita =>20% ICU KPI | C | (SE.2.1.1) |

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| | | | 2. Mobile broadband internet subscription/100 capita | C | (SE.2.1.2) |
| | | | 3. Fixed broadband internet subscription /100capita | C | (SE.2.1.2) |
| | | (SE.2.2) Employment | 1. City's unemployment rate ISO37120 /5.1 | C | (SE.2.2.1) |
| | | | 2. Employment rate for every 100 capita 67 | C | (SE.2.2.2) |
| | | (SE.2.3) Poverty | 1. % of city population living in poverty | C | (SE.2.3.1) |
| | | (SE.2.4) GRP | 1. Gross Regional product (GRP) | C | (SE.2.4.1) |
| Smart Economy (SE) | (SE.3) International Embeddedness | (SE.3.1) Export | 1) % of GDP based on foreign exports | A | (SE.3.1.1) |
| | | (SE.3.2) Attractivenes s for a city for foreign investment | 1. network of industrial and commercial areas including: business parks, specialized free zones of international distinction, a world class seaport, a major international airport, a cargo village, a modern highway network, state-of-the-art telecommunicat ions, and reliable power and utilities. | A | (SE.3.2.1) |
| | | | 2) International conferences and fairs | A | (SE.3.2.2) |

**Table (6): Key indicators for Smart People** (by the Author)

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| Smart People (SP) | (SP.1) Education | (SP.1.1) Primary and secondry Education | 1. % of students completing Primary Education ISO37120/6.2 | C | (SP.1.1.1) |
| | | (SP.1.2) Student teacher ratio | 1. Primary education student to teacher ratio ISO37120/6.3 | C | (SP.1.2.1) |
| | | (SP.1.3) College Education | 1. College education (number of higher education degree for 100,000 | C | (SP.1.3.1) |
| | | (SP.1.4) Adult literacy | 1. Adult literacy rate | A | (SP.1.4.1) |
| | (SP.2) Inclusion | (SP.2.1) Student ICT classroom access | 1. % of students with classroom access to ICT facilities | C | (SP.2.1.1) |
| | | | 2. Smart phones penetration (% of residents with smartphones access) | C | (SP.2.1.2) |
| | | (SP.2.2) Civic Engagement | 1. Civic engagement (% of civic engagement activities offered by municipality last year) | C | (SP.2.2.1) |

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| | (SP.3) Creativity | (SP.3.1) Plurality | 1. Social and Ethnic plurality | A | (SP.3.1.1) |
| | | (SP.3.2) Creative Industry | 1. Creative Industry Jobs | A | (SP.3.2.1) |
| | | (SP.3.3) Urban Living Lab | 1. Urban living Lab | A | (SP.3.3.1) |

**Table (7): Key indicators for Smart Environment** (by the Author)

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| Smart Environment (SE) | (SE.1) Energy | (SE.1.1) Monitoring Energy | 1. Development of a database to monitor energy consumption footprint (kWh/m2) in buildings Total residential Energy use per capita in KWH /year ISO 37120 /7.1 | C | (SE.1.1.1) |
| | | | 2. Total Public building energy use per Capita in KWH/Year ISO37120/7.3 | C | (SE.1.1.2) |
| | | (SE.1.2) Renewable Energy | 1. The percentage of energy driven from renewable energy sources in kwh/Yr as a share of total energy consumption ISO 37120 /7.4 | C | (SE.1.2.1) |
| | | (SE.1.3) Electric Energy | 1. % of city population with authorized electric energy | A | (SE.1.3.1) |
| | | (SE.1.4) Set Targets | 1. Set targets for clean energy power capacity via 25% 2020 and 75% by 2030 | A | (SE.1.4.1) |
| | (SE.2) Sustainable and Resilient Resources Management | (SE.2.1) Waste Management | 1. Waste management (% of solid waste recycled ISO37120/16.2) & total collected solid waste /capita in Kg ISO 37120/16.3 | C | (SE.2.1.1) |
| | | | 1. % of city water receiving primary, secondary, tretiary treatment ISO 37120 ISO 37120 20.3/ 20.4 /20.5 | C | (SE.2.2.2) |

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| | | | 2. % of commercial buildings with smart water fittings | A | (SE.2.2.3) |
| | (SE.3) Sustainable Urban Planning | (SE.3.1) Air Quality and carbon footprint | 1. (Greenhouse gas emissions measured in ton/capita 5.5 Urban stakeholders should focus their efforts on reducing the carbon footprint of their city (in line with the COP-21 targets and SDG13 ) Fine Particulate Matter (PM2.5) And particulate matter (PM 10) | C | (SE.2.2.1) |
| | | (SE.3.2) Green area | 1. Green area /100,000 in m2 ISO 37120 /19.6 | C | (SE.3.2.1) |
| | | (SE.3.3) Climate resilience | 1. Climate resilience Planning Density | A | (SE.3.3.1) |
| | | (SE.3.4) Smart buildings | 1. Promoting green and innovative building Systems in construction and buildings (vernacular Architecture, BIM,, self healing concrete and new construction methods Hamdy et al (2018) | A | (SE.3.4.1) |

**Table (8): Key indicators for Smart Living** (by the Author)

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| Smart living (SL) | (SL.1) Culture and wellbeing | (SL.1.1) Budget Allocated to Culture | 1. % of municipal budget allocated to culture | C | (SL.1.1.1) |
| | | (SL.1.2) Gini Index | 1. Gini Index of zero expresses perfect equality | C | (SL.1.2.1) |
| | | (SL.1.3) Quality of life(Housing) | 1. Quality of life ranking | A | (SL.1.3.1) |
| | | | 2. Education facilities | A | (SL.1.3.2) |
| | | | 3. Housing quality | A | (SL.1.3.3) |
| | | | 4. Social cohesion | A | (SL.1.3.4) |
| | | | 5. Touristic attractivity | A | (SL.1.3.5) |
| | (SL.2) Safety | (SL.2.1) Crime | 1. Crime (number of crime rate for 100,000 population 14.5) | C | (SL.2.1.1) |
| | | (SL.2.2) Crime prevention | 1. Smart crime prevention | A | (SL.2.2.1) |
| | | | 2. Number of police officers for 100,000 population | C | (SL.2.2.2) |
| | | (SL.2.3) ICT and Artificial Intelligence (AI) Applications | 1. Smart police Applications of ICT and AI(artificial intelegence) | A | (SL.2.3.1) |
| | (SL.3) Health | (SL.3.1) Single Unified Health History | 1. Single health history (% of residents with single unified health history facilitating patients and health provider access to complete medical record) | C | (SL.3.1.1) |

| DIMENSIONS | SUBDIMENSIONS | KEY INDICATORS | DEFINITION/ DESCRIPTION | TYPE/ REFRENCE | |
|---|---|---|---|---|---|
| | | (SL.3.2) Health Services | 1. Number of inpatient hospital beds /100,000 | C | (SL.3.2.1) |
| | | | 2. Number of physicians for 100,000 population | C | (SL.3.2.2) |
| | | (SL.3.3) Life Expectancy | 1. Average life Expectancy | C | (SL.3.2.3) |
| | | (SL.3.4) Recreation | 1. Square meter of public outdoor and indoor recreation facilities | A | (SL.3.4.1) |

### 3.4. Collective methodology for key Indicators (Appendix A) as developed by ITU-T

A collective methodology for core indicators implemented by Information Telecommunication Union ITU-T is attached (Appendix A). This Model has been chosen because it has been applied on physical cities like Dubai (Appendix B) and Singapore to measure success, develop guidelines policies and recommendations for each city and enhance global smart sustainable cities Index (Figure 5). In the model developed in this study each core key indicator is linked to its associated collective methodology table through a reference number illustrated on the key dimension tables


Figure 5 Key Indicators developed by ITU-T and their application on physical Cities (Dubai and Singapore)

# CHAPTER 4: RESULTS AND DISCUSSIONS

## 4.1. United for Smart Sustainable Cities

The United for Smart Sustainable Cities Initiative (U4SSC) was established on 18 May 2016 as a study group of the United Telecommunication Union. The group was established through a collaboration of the ITU and the United Nations Economic Commission of Europe (UNECE) this study group serves as an international platform for sharing knowledge about the Information Communication Technology(ICT) and for advancement of ICT to achieve Smart Sustainable Citie around the globe. sestablished the United for Smart Sustainable Cities Initiative (U4SSC), which serves as the international platform for knowledge sharing and developing best practices linked to smart sustainable cities. This global platform has been created in response to United Nations Sustainable Development Goal 11:"Make cities and human settlements inclusive, safe, resilient and sustainable." This initiative has been open to countries around the world to participate and contribute towards its work, Unlike other smart city platforms. U4SSC is now a UN initiative supported by 16 United Nation agencies and programs (ECLAC), (FAO), ITU, (UNDP), (UNECA), UNECE, (UNESCO), UNEP , (UNEP-FI), UNFCCC, (UN-Habitat), (UNIDO), (UNU-EGOV), (WMO) to achieve Sustainable Development Goals

ITU-T has developed a set of key performance indicators (KPIs) through its Study Groups to existing assist cities in transforming to smart sustainable cities integrating ICT services into their existing urban operations.

The Key performance indicators (KPI) developed by this study group are available in Recommendation ITU-T Y.4901/L.1601, Key performance indicators related to the use of information and communication technology in smart sustainable cities and ITU-T Y.4902/L.1602, KPI related to the sustainability impacts of information and communication technology in smart sustainable cities. These KPI has been applied on physical cities like Dubai and Singapore to measure success of cities and as a monitoring measure for their transition to smart sustainable cities, develop guidelines policies and recommendations for each city and enhance global smart sustainable cities Index.

## 4.2 Comparative Analysis of the Model adopted by ITU-T and the one adopted Yale University and AUC

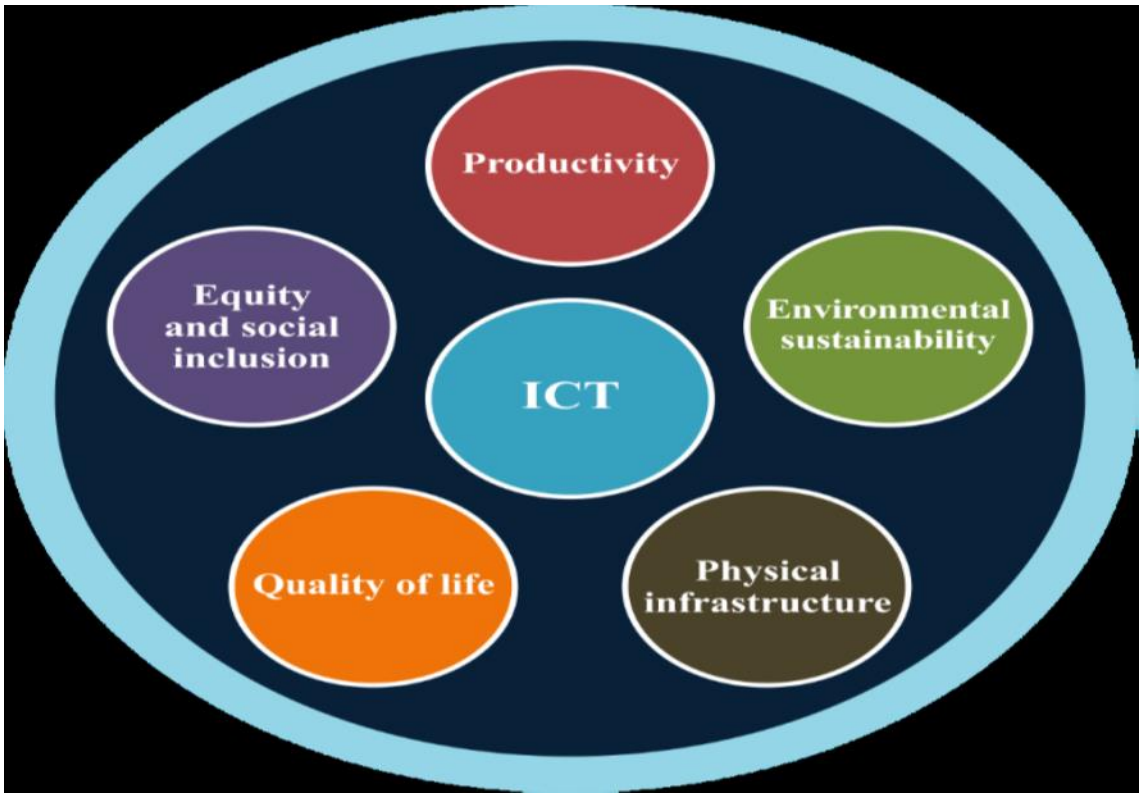


Figure (6): Dimensions implemented by ITU-T

- ITU-T group has developed key dimension model, in this model, ICT has been identified as a Key dimension and an objective by itself
- The model developed by ITU-T used the quality of life as one of the dimensions of SSC, in-contradiction to what researchers agreed upon, that the quality of life is a cross cutting concern for all dimensions and should not be used as a key dimension.
- In the dimensions implemented by ITU , ICT is defined as a separate category to highlight the focus of ITU-T, which developed a framework of policies, standards and guidelines on the role of information communication technologies (ICTs) in creating smart sustainable cities.


Figure (7): Key Dimensions adopted by Yale University and AUC

- Fearing that the sustainability aspect in smart cities might be overlooked, the ITU Telecommunication Focus Group on Smart Sustainable Cities (ITU-T FGSSC) conceptualized the new term "Smart Sustainable Cities" and developed a new definition on October 2015, definition that was listed in Chapter 2 figure 1
- After critical analysis of the literature, this definition provides a standardized basis for assessment models that has been adopted on the global level, It is oriented towards achieving aspects of urban life in the Smart Sustainable City context, hence it is the most suitable to be adopted and used in this study.
- The model developed by ITU-T used the quality of life as one of the dimensions of SSC, in-contradiction to what researchers agreed upon, that the quality of life is a cross cutting concern for all dimensions and should not be used as a key dimension.
- A new model for Key dimensions was developed by ITU-TFGSSC and it is the model adopted in this study, Figure 6
- The ITU-TFGSSC did not develop sub-dimensions or key indicators for their key dimensions Model. Hence, this study was conducted to develop new sub-dimensions and key indicators model to fill this gap.

- The new model was developed in collaboration in research between AUC and Yale University
- In the dimensions adopted by AUC and Yale Universities ICT forms part of the general 'Infrastructure' category. In this model ICT is a mean to achieve development, instead of technology as the master, it has been made to serve development. The general goal is to improve sustainability with the help of technology. The aim of the framework of policies, standards and guidelines developed is to highlight the role of smart sustainable urban planning in creating smart sustainable cities.
- The key indicators are more oriented to provide cities at the planning and design stage with a credible frame work, when adopted at this stage.

### 4.3. Comparative analysis of case studies (Singapore and Copenhagen)

Denmark and Singapore are both small nations with a population of about 5.5 million people (Administrative Capital population is expected to be 6.5 million), and have developed strong expertise in maximizing the use of scarce resources. Water technology and public transport are two main areas where Copenhagen and Singapore are looking to learn from each other. The two countries are already partners in the water sector, having jointly set up the Water & Environment Research Centre and Education Hub in 2007, and the Danish Water Technology House in 2014.

Denmark has a long tradition for designing urban development solutions that benefit the goals of their people, businesses and environment. Copenhagen, with its vision to be fossil independent by 2050 and carbon neutral by 2025, is a role model for sustainable and liveable cities. As leaders in smart cities, Singapore and Denmark have much to share and learn from each other and to share their experience with the world in an attempt to lead the world in transforming its cities to smart sustainable cities. Our industries and think can come together to provide real solutions that the world needs urgently to solve its challenges," said Berit Basse, Ambassador of Denmark to Singapore. Copenhagen falls within the category of large cities, and its success in the field of smart cities makes its strategy an ideal sample to analyze. This success is demonstrated by the multiple awards that the city has received during recent years and its international positioning as a smart city. One of the most important award comes from the European Parliament, which has included the Dutch capital among the six most successful smart cities in Europe (Manville et al. 2014).

**Smart nation and digital government Initiative**

Singapore has developed a smart nation and digital government initiative and has assigned a new group founded under the Prime Minister office (Smart Nation and Digital Government Group, (SNDGG)) to be in-charge of setting goals and monitoring progress to transform Singapore to a smart sustainable city. Administrative Capital Cairo, announced as a first Egyptian smart city needs to have an office to be founded under the prime minister office to set targets and means for developing smart sustainable Administrative Capital Initiative and to orchestrate multi-agency to achieve those goals. Singapore has announced a pilot area to implement smart indicators to illustrate how the proposed framework by ITU-T might take physical form on a given site. In Copenhagen, Created by the City of Copenhagen, The Copenhagen Solutions Lab has set up pilot areas across the city to test innovative physical solutions under real urban conditions. Street Lab, for example, is a test area in the heart of the city designed to use network technology and sensors to achieve smart sustainable urban development through reducing air pollution and noise, optimizing waste collection and water management, and providing intelligent parking. This has helped in achieving open standards that promote innovation around ICT and smart Technology. Citizens, private companies, policy makers and researches are invited to participate in the open innovation process through an application process that is accessible to the citizen. Participants just need to present their ideas and if The Lab has established open standards to help strengthen innovation around smart city technology. The Lab invites citizens, policy-makers, companies, and researchers to the join the open innovation process through an accessible application process. Organizations just need to submit a brief description of their idea and if it meets certain criteria the lab guides the applicants to transforming their ideas into actual solutions for enhancing technology applications towards achieving smart sustainable goals.

**Green Energy**

Egypt is only making efforts to offset energy consumption and GHG emissions by investing in systems like building solar power utility station in the neighborhood to provide cool air to commercial buildings, public buildings We are looking for systems like this to service more of our neighborhoods around the city and not only tall buildings. They should be integrated into our urban fabric and be

interactive with local residents on a physical and digital level. The government should present a solar system model to the residents to be implemented by all house owners and provide incentives for implementations. Vancovar is an innovative city it relies on photovoltaic (PV) solar panels for most of its electricity needs. These PV panels are installed on each house studio in the district, and members share the energy they produce using a crypto currency token" Members can also visualize and manage local energy production and consumption, make transactions with one another, or even trade goods at its local cafe online. Building a sharing platform into a system like this can also enable Egyptians to benefit from energy that is harvested in their own neighborhoods.

Example of incentives for promoting use of Solar Energy:

1. **30% tax credits**

Allows taxpayers, who own a home in Egypt, and who reside in that home, to claim a tax credit for qualified expenditures related to the installation of a solar PV system.

2. **Net meter**

Allows selling Excess energy generated to the Utility Company

3. **Solarize Adminstrative Capital**

offer communities the opportunity for making the decision to purchase and have a solar PV system installed on their home or business while taking advantage of cost savings with group purchasing. The private sector could develop a model for Solar Energy, integrated with pent house hydroponic planting (planting without a soil by using nuterients ingredients dissolved in water

On the other hand Singapore is monitoring its water distribution to ensure fair distribution and good quality of water. Air quality is also being monitored 24 hours and green gas emissions. A one service application has been launched that allows the users to communicate with municipal services and receive environmental news and enhance interaction between different governmental agencies. Figure7

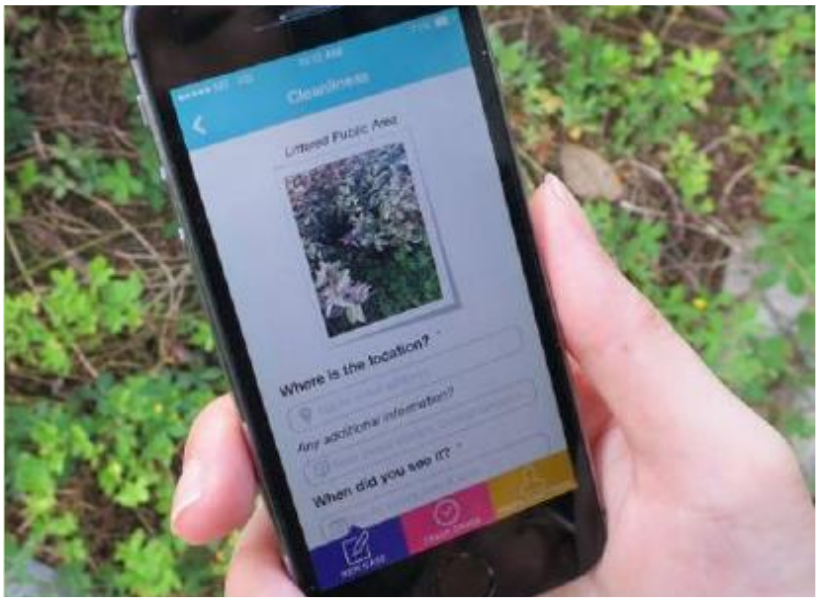


Figure (8): One Service Application

**(Implementing ITU-T international standards, case of Singapore)**

**Housing**

We live in a divided city, where the number of upscale housing and disadvantaged neighborhoods continues to rise and the middle low income neighborhoods are disappearing. The government has to think of building more affordable houses. Experiment with unconventional building materials, Biocompatible materials with circular cradle to cradle lifecycle can challenge and improve the way we build smart sustainable buildings. Introduce new textures, colors, forms, and experiences as public art into our environment. Building Information Management (BIM) should be integrated in all levels of design to ensure full coordination between architecture, structural, electromechanical and plumbing. The BCA Green Mark scheme was launched in 2005 as an initiative to drive Singapore's construction industry towards more environmental-friendly buildings. The city is building a 3D model for the whole city to facilitate for citizens visualizing any change that is taking place in the city and share their view and feedback through a platform that was developed specifically to facilitate this integration. Smart housing does not necessarily mean high rise with glass.

**Mobility**

We must think of New and innovative transit options to connect different neighborhoods and city areas through. Cycling or pedestrian pathways Administrative Cairo must be better connected to existing recreational and cycling routes such as the Don Valley systems, by creating priority cycling- and pedestrian-friendly traffic lights and pathways along their path. Cycling, walking, and public transit routes in Copenhagen span the whole city: These cities presented many opportunities for multimodal trips. For example, you could travel from Central to North by taking your bicycle on a city barge. In Administrative Cairo, you should be able to not only cycle across the city, but also transport your bicycle with ease by using transit options. The Buses are equipped with bicycle carriers figure 8 that allow commuters to carry their bicycle in the bus to continue their trip. Cyclists should be able to connect their bicycle routes to other areas of the city by leveraging public transit. It should be noted that Figure 8 illustrates bike sharing In Copenhagen Also limits on private cars use should also be increased, for example increasing parking fees in downtown areas help people to use multimodal transport systems.

Figure (9): Bike sharing in Copenhagen

**(https://en.wikipedia.org/wiki/Bicycle-sharing_system)**


Figure (10): Bus carriers for bicycles

**(https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved)**

**Autonomous vehicles**

Singapore is one of the leading cities implementing the use of Autonomous vehicle by2020 as one of its multimodal transport system(Figure 10) with a goal to replace 25% of private vehicles usage by Autonomous cars. Let's take a look of some of the benefits of using driverless vehicles:

1. **Reduced accidents**

95% of car accidents is attributed to human error by using Autonomous vehicles technology this will reduce deaths and injuries on the roads by 90 percent, especially those that results from driver distraction and human error.

2. **Reduce traffic congestion**

Human driving normally creates stop and go traffic this is well known Phenomena to traffic researchers called "Phantom traffic Jam". According to a study c

onducted by Daniel B. Work, assistant professor at the University of Illinois at Urbana-Champaign, a lead researcher in the traffic congestion study, by using as little as 5% of vehicles being automated vehicles we can eliminate stop and go waves that are caused by human driving and smooth traffic for cars.

3. **Reduce $CO_2$ gas emission**

Reducing congestion of cars will result in reduction of $CO_2$ gas emissions, the autonomous cars can be programmed to reduce gas emission by 60% according to Future of Driving report from Ohio University States.

4. **Increased lane capacity**

Autonomous vehicles could increase express roads capacity by 100% and their speed by 20% Research from the State Smart Transportation Initiative (SSTI5.

5. **Lower fuel consumption**

Using Autonomous vehicles Technology can reduce fuel consumption by 4-10 by controlling the stop and go flow of the car. An experimental study that was done by University of Illinois researchers that even using a small percentage of Autonomous vehicles on the road can reduce the total fuel consumptions by 40%

6. **Transportation accessibility**

Due to advancement in health services the number of senior citizens continues to rise in many cities. The population of senior citizens The USDOT website states: "Many seniors and people with disabilities cannot currently drive, even with vehicle modifications that help others drive safely. Autonomous vehicles could provide many more Americans access to the open road and to independence." This could provide services for senior citizens and handicapped like going to the doctor and visiting family members.

7. **More efficient parking**

Some cities devote more than third their land for parking by using autonomous vehicle that can drop the people to their final destination and park somewhere else will reduce the large areas required for parking. Urban areas facing acute space parking does not need more space that are required by regular cars to open the doors for the driver and hence vehicles will be more stacked to park closer and consume less space


Figure (11): Autonomous vehicles

**(www.navya.tech)**

## ICT and IoT

Next Generation for Singapore's Nationwide Broadband Network (Next Gen NBN) is the wired network of the Next Generation National Infocomm Infrastructure (Next Gen NII). Under the intelligent nation plan, this project 2015 (iN2015)14 master plan, will transform Singapore into "an intelligent nation and global city, powered by ICT and IoT more than 95% of homes and businesses will have access to the network. The next generation of ICT will be implemented the Heterogeneous Network (HetNet) to strengthen Singapore's connectivity framework. Their ultimate goal is to allow everyone and everything to be connected all over Singapore everywhere, at any time by 2025. This advancement in ICT infrastructure will pave the way for more innovation.

### 1. Wireless @Singapore

Singapore has increased targets to install more hotspots at different locations 14,000 by 2018 and 20,000 by 2020 this will allow free access by the public to the net in public areas like community centers, public transportation, train stations, libraries and shopping malls.

2. **Cross border connectivity**

Singapore has extended submarine cables infrastructure super sea cables network to allow for more connectivity outside its boarder through a consortium with china telecom and other service providers to connect with Perth by 2018

3. **Government ICT Infrastructure**

The Singapore government has built data hubs and scalable data and information platforms that service the people in data analysis, sharing and service delivery. MYINFO is one of these platforms that contain personal information that allows the government to pull any information about the person and save people the trouble of keying in these information. The city has deployed more than 300 mobile government services which indicates the city commitment to implement ICT in the services provided to it's citizens. Furthermore**,** Singapore has recognized the importance of cyber security on 2016 the government launched the cyber security strategy

4. **Non ICT Infrastructure**

This includes basic non ICT infrastructure that supports the economy and provide basic services: Electricity, Water, Sanitation, Energy, Waste Management, Roads and Public Transportation. The efficiency of the public transportation services in Singapore is demonstrated by the fact that two third of the population commute to work by public transportation.

5. **The Smart Nation Sensor Platform**

The city is implementing next generation sensors coverage for all services (Electricity, water, energy and waste) figure 11.

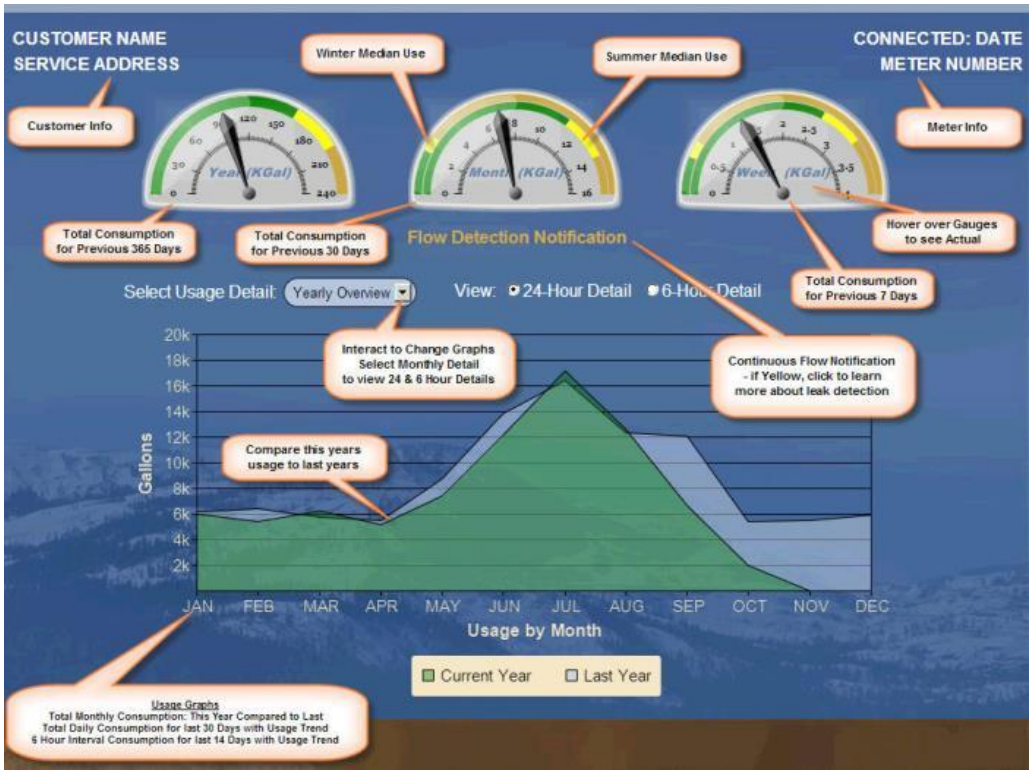


Figure (12): Sensors for all utility services

**(www.tdpud.org)**

## 6. Productivity Dimension

Singapore is enabling start-ups and innovation hubs to empower big data and analytics technologies, and next-generation sensor. Enabling these technologies will attract people from around the world to take advantage of Singapore's infrastructure and display their innovations. This will create an Environment in which new ideas can be tested through start-ups, research centers and partnerships with universities. Singapore has launched Building Amazing Start-Ups Here (BASH) which allows startups to use all the resources required to transfer their ideas into action plan and commercial under one roof. Innovation hubs can be used to develop new technologies that will attract investors to take advantage of this innovative environment. Tech Park is a living example of the strong presence of venture capitalists and multinational companies. The country also tops the global ranking for start-up talent (ahead even of SiliconValley). Singapore is opening it's Fintech lab to act as a platform for financial technology, building technology hubs and manufactory centers and using metering and sensors. Singapore is also partnering with Microsoft on "Conversations as a Platform" to explore options in creating next generation e government services opportunities in co-creating next-generation digital government services.

7. **Equity and Social Inclusion**

Singapore has developed ICT and open data to help government to engage with citizens and the public to have access to information on government services and performance. Building on sensors around the city helps the city to track traffic at intersections and provide the citizens with real-time updates, boost telecommunication signals at crisis time building resilience of the city at flood and at drainage points with early alarm sensors placed at drainage point.

**Quality of Life**

Singapore has laid a strong foundation for implementing ICT in the national educational system to build capacity of teachers and integrate ICT in the educational process to support the educational experience of students. Singapore has launched the Schools learning Space, an online portal that supports the educational experience for both the teachers and the students. Through the SLS, all students will have equal access to all educational resources, learning is made more interactive through videos, animation, simulations and games and online quizzes. The SLS has been designed in compliance with the industry needs and real world challenges. Every student will have equal access to quality online learning resources. With respect to health

## 4.4 Comparative analysis of Sidewalk Toronto as a case study for a new city to be built as a Smart Sustainable City

We need to apply innovative thinking in design like building a freight tunnel and infrastructure tunnel beneath the cities this will reduce building energy consumption, landfill waste, and carbon emissions—creating a blueprint for truly climate-positive neighborhoods. Garbage vehicles and autonomous cars travel the area out of pedestrian ways, Figure8**.** Establish a living laboratory for urban planning and civic technology experimentation in one of the districts applying different and innovative methods of construction innovative physical solutions under real urban conditions. Choose the most successful and implement for a pilot area at first, then all over the city.

Figure (13): Sidewalk Toronto Freight Tunnel

(www.theglobeandmail.com/news/toronto/google-sidewalk-toronto-waterfront/article36612387

Sidewalk Toronto urban planning approach

- Sidewalk Toronto is bringing planning community and technology together.
- We have the opportunity how urban planning can redefine the way we build our cities in the twenty first century
- How data can help improve city services.
- They are committed to an open platform that others can innovate upon.
- Empowering local start-ups, research in universities to create solution

# CHAPTER 5: ASSESSMENT SCHEME OF THE NEW ADMINSTRATIVE CAPITAL

## 5.1 Background (Cube Consultants 2016)

### 5.1.1Vision

As part of the Egyptian Government's development strategies, the vision for the Capital Cairo is a product of the collaboration of the Egyptian Ministry of Housing and Capital City Partners Ltd, a private fund of global investors, aided by the internationally renowned design firm Skidmore, Owings & Merrill LLP (SOM). SOM city planners developed the initial framework and core principles of a sustainable new city. Designed in harmony with the local environment and shaped by the natural landscape, the vision for this new city was created to specifically meet the needs of a modern city with a burgeoning economy. The final design has been further developed by 5+ Urban Planning Consortium (UPC).

### 5.1.2 Location

The location of the new capital was chosen to be an extension of the current capital, it extends Cairo's east between the way of "Cairo - Suez, "and" Cairo - Al Ain Sukhna ", east of the regional ring road, 45 km from the center of Cairo, 80 kilometers near the city of Suez, also near the Red Sea, which gives it a logistical advantage and strategic benefits. Approximately 700 square kilometers in area, with 200 square kilometers of preserved natural areas and one of the largest city park systems in the world, The Capital Cairo will be linked to historic Cairo through extensive public transit links. The city vision allows for flexibility to respond and adapt to the regional economic trends over the course of many decades. The vision has been carefully planned to accommodate a growing population, from over seven million people across all income groups, when fully realized.

### 5.1.3 Master Plan concept

The planning idea consist on creating natural oasis, valid for the development, that links between them green axes to emphasize the concept of a green city, while taking into account the nature and the topography of the site, corridors, streams, torrents of rain in the site as a whole. Also it provides

entertainment hubs while taking advantages of the storm water drains, by converting it into a green axis. Therefore, the whole strategic planning idea for the site depends on the integration, urban and economic interdependence with the surrounding national projects through the land usage and proposed network of roads. Thus the coherence is achieved with the national project for the development of the Suez Canal region. As well as the central foundations design of the central region, that extends rectangular CBD (surrounded by residential neighborhoods, and each neighborhood has its own center. Allocated at the end of the project area technological industries, sports activities and universities where it is difficult to be within the project. The unique site is defined by wadis and a unique topography, which will be preserved and enhanced for future generations. The future city will be compact in urban form and anchored by concentrated development districts, including a central business district, a government administrative district, a cultural district, a knowledge and innovation district, and over 100 diverse residential neighborhoods. The new city will be designed and built in harmony with nature as a show case of environmentally sensitive development as illustrated in Figures 14,15. The Design provides a framework for the adaptations required to meet the challenges presented by climate change and sea level rise, including the exacerbated effects of storms, and rainfall

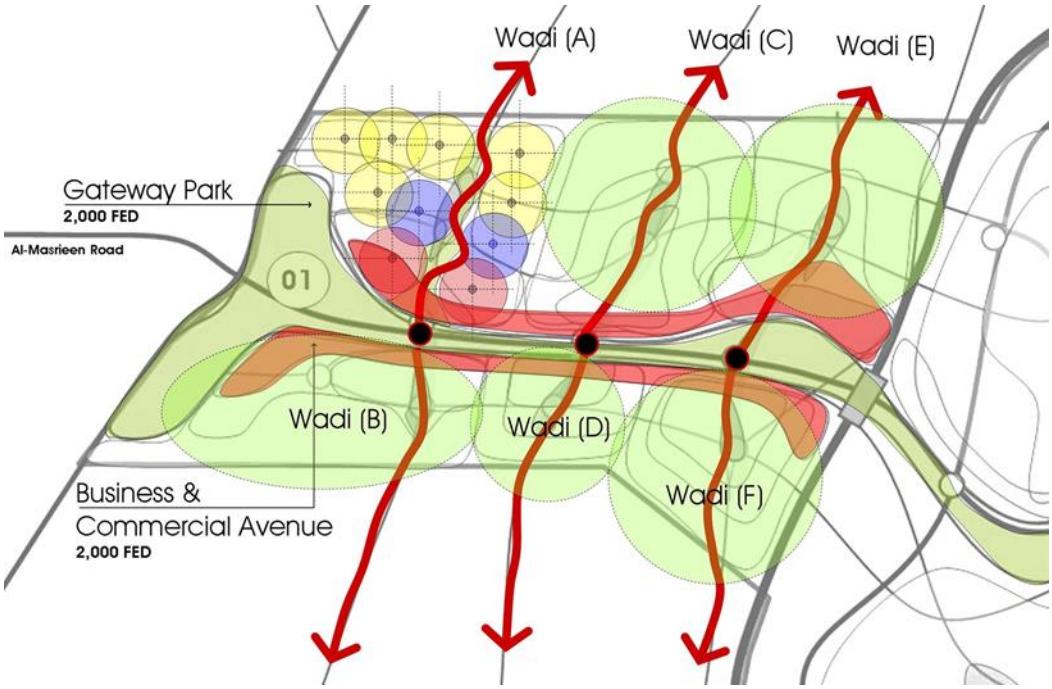


**Figure (14): Master Plan Concept** ( https://cubeconsultants.org/home/)


Figure (15): Phase one Capital Cairo

( https://cubeconsultants.org/home/)

The Planning process of administrative capital project relies heavily on green resilience strategies that include perimeter surge protection, dry egress, green infrastructure, storm water management and utility micro grids that have been integrated through a comprehensive urban design framework with strategies for economic development, urban connectivity, and transit. Based on an extensive engagement with state and municipal agencies, institutions, nonprofits, business owners, residents and other stakeholders, the project establishes a vision for a city that is vibrant, safe and flexible, with new opportunities for development and recreation, and an attractive blue-green public realm.

## 5.2. Assessment for Administrative Capital

Table (9): Comments of Key indicators for smart mobility

| KEY INDICATORS | | | COMMENTS |
|---|---|---|---|
| (SM.1.1) Public Transportation | 1) Kilometres of annual high& low capacity public transport trips /100000 ITU-T | | Administrative Capital will have high capacity transportation as speed train) and Low capacity (Buses, bus rabit transport) |
| | 2) Transportation mode share% of commuters using transport other than a vehicle ITU-T | | In Singapore the efficiency of the puplic transportation system is illustrated by the fact that two third of the city population commutes to work by public transportation |
| | 3) Central underground Metro stations to be connected to City | | New administrative Capital does not have an underground metro station .Shuttle buses can be used to transfer people to nearest metro station |
| | 4) Bus Rapid Transit BRT in addition to franchised buses by private sector (all using clean energy) | | The government has announced using electric buses only in the city. Electric buses or biogas buses can be used as a clean transportation method |
| | 5) New Railway development strategy and speed trains | | A speed train will be connecting the city to Alsalam and10th of Ramdan city |
| | 6) More carpooling and sharing activities with incentives like free parking and free gas | | The private sector or the city should develop a shared platform that could coordinate carpooling with incentive being announced for owners of the cars like free parking and free gas |
| (SM.2.1) ICT and Internet of Things (IOT) | 1) No of Fixed Broadband Subscription/100000 population ISO37120/7.1 | | A higher penetration rate means that more of the population have access to knowledge and communication an increase in number is a positive indication |
| | 2) No of Wireless broadband Subscription /100000 population ISO3 7120/7.2 | | This indicator reveals the level of advancement in communication technology available to the public |
| | 3) % of the city served by Wireless broadband Coverage 4G and 5G<br>4) Availability of Wi Fi coverage in public areas | | The ultimate goal is at least 95% of the city should be covered The city should start by providing hot spot at public areas the ultimate goal is to have accessibility at all places at any time |

| | | | |
|---|---|---|---|
| (SM.2.2) Monitoring and Real Time Information Technology | 1) % of Dynamic public transport information available to the public in real time | | Investing in public transport is one of the most efficient ways to move people around the city. Providing riders with information on the status of the system along with the arrival and travel times (i.e. dynamic information) will encourage transit use. |
| KEY INDICATORS | | | **COMMENTS** |
| | 2) % of road intersections using adaptive traffic control for light signals or prioritization measures | | This means change of road signals according to traffic flow, which decreases the idle time by cars. An increasing trend is considered positive |
| | 3) % of major streets monitored by ICT | | Major streets and express roads should be monitored, residential should not be included, this monitoring highways and main roads allows better management for traffic congestion |
| | 4) Real time for parking spaces available | | Having information about parking spaces in real time will decrease congestion and allows for better traffic flow and less idle time |
| | 5) Metering and Sensors Coverage for services (Electricity, water, energy , waste) | | The city should implement next generation sensors coverage for all services (Electricity, water, energy and waste) |
| | 6) Build technology hubs and advance manufactory centres | | Establish a living laboratory for urban planning and civic technology experimentation at different pilot areas. Build Innovation and technology parks as Silicon valley |
| | 7) Develop a scalable data platform for smart city data sharing | | A single platform for all the above mentioned services will allow better coordination and implementation |
| (SM.3.1) Innovative and Safe | 1) % of total trips of public transport achieved with smart cards | | The application of using a single smart card for all modes of public transportation |
| | 2) International Easy and Efficient Travel with Smart Airport | | A new Airport is being built at New Administrative Capital it should implement all ICT and IoT to achieve best experience for all travellers |
| (SM.3.2) Non-motorized options | 1) % of bicycle paths for 100,000 ISO37120 /18.7 | | It should be noted that for every kilometer travelled by bicycle instead of by car, Denmark gains approximately €1 in terms of health benefits, resulting in nearly €215 million saved each year |
| | 2) Promote walking through pedestrian | | This can enhance pedestrian experience and allow people to use this option for |

| | | | |
|---|---|---|---|
| | finding and recommend walking routes | | commuting |
| | 3) Establish "bicycle-friendly" new towns with cycling tracks and bicycle parking facilities and applications | | Administrative Capital should implement cycling sharing and its applications. Cyclists should be able to connect their bicycle routes to other areas of the city by leveraging public transit. |

Table (10): Comments on key indicators for Smart Government

| KEY INDICATORS | DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SG.1.1) ICT aimed at improving access to information and building capacities | 1) e-governance Number of public services delivered through electronic means | | This aims at making public services delivery more effective, accessible and responsive to people's needs. It also supports public policy and service delivery |
| | 2) e-procurement Percentage of public sector procurement activities that are conducted electronically | | The ultimate goal is to achieve all transactions that occur during procurement through websites, web portals, and mobile applications |
| | 3) Unified access point for all government services on a single plat form | | Develop an application architecture framework and implement a central platform for different government services. A new integrated cloud infrastructure needs to be developed to accommodate future smart city applications. This will allow better coordination and implementation to assess growth and sustainability |
| (SG.2.1) Electricity | 1) Electricity Supply, Percentage of households with authorized access to electricity | | Administrative Capital should have all buildings designed with non ICT main infrastructure. (water, electricity, sanitation, waste collection and transportation Available for users |
| | 2) Electricity System Outage Time Average length of electrical interruptions | | |
| | 3) Electricity System Outage Frequency, Average number of electrical interruptions per customer per year | | |
| (SG.2.2) Water and Sanitation | 1) Basic water supply Percentage of households with access to a basic water supply | | Customer Average Interruption Duration Index (CAIDI) is used as a standard reliability indicator by |

| KEY INDICATORS | DESCRIPTION | | COMMENTS |
|---|---|---|---|
| | 2) Potable Water Supply Percentage of households with a safely managed drinking water service | | electric power utilities globally and indicates how long it will take to restore electricity once an outage has occurred. Lack of access to main services will contribute to poverty and limits economic development |
| | 3) Sanitation, Percentage of households with access to basic | | |
| | 4) sanitation facilities | | |
| (SG.2.3) Waste | 1) Solid waste collection | | |
| (SG.2.4) Transportation | 1) See smart mobility Dimension | | |
| | 2) Sensors and meters coverage for monitoring services consumption | | The city should implement next generation sensors coverage for all services (Electricity, water, energy and waste) |
| (SG.3.1) Open Data | 1) Use central data management to assess growth and sustainability | | A single platform for all the above mentioned services will allow better coordination and implementation to assess growth and sustainability |
| | 2) Privacy | | Review and implement best practices for cyber security, raising awareness and educating users on best practices, continuously updating guidelines and strategy for IoT security |
| | 3) Voters participation in last municipal election as a percentage of eligible voters | | This is an indication for more democracy and participation of the people |

Table (11): Comments on key indicators for smart economy

| KEY INDICATORS | DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SE.1.1) R+ D | 1) % of GDP invested in Research and Development (R +D in private sector) | | An increasing trend in this indicator is positive. Create an Environment in which new ideas can be tested through start-ups, research centers and partnerships with universities. Expand research and development platform through building Innovation and technology parks as Silicon valley. |
| (SE.1.2) Patents | 1) Number of Patents for 100000 population ISO 37120 5.7 | | Patents demonstrate the efficiency of the government to transform research into products and increase in trend is an indication of healthy economy and innovation. It allows information sharing |
| (SE.1.3) Entrepreneurs hip | 1) Assessed value of total commercial and Industrial properties as a percentage of total assessed value of all properties | | An increase in number of businesses is a positive indication |
| | 2) Number of Businesses for 100000 population ISO37120 5.6 | | An increase in number of businesses is a positive indication |
| | 3) Facilitate business licensing and registration to foster entrepreneurship in the city | | Create a one window one place business licensing and registration to promote innovation and new businesses |
| | 4) Develop economic plans and policies, identify and support the growth of strategic sectors, and provide services to domestic and international investors and businesses. | | Innovation hubs can be used to develop new technologies that will attract investors to take advantage of this innovative environment.Strategic sectors like, FinTeck, construction, Environmental and ICT |
| (SE.2.1) Productivity | 1) Broad band internet connectivity /100 capita => 20% ICU KPI | | An increase in broad band internet connectivity, is an indication for increase of productivity an increase in trend is a positive indication |

| KEY INDICATORS | DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SE.2.2) Employment | 1) City's unemployment rate ISO37120 /5.1 | | Unemployment signals a weak economy with slow growth and spending. It is a national target that is set by central bank |
| | 2) Employment rate for every 100 capita 67 | | An increase is a positive indication |
| (SE.2.3) Poverty | 1) % of city population living in poverty | | An increase is a negative indication |
| (SE.3.1) Export | 1. % of GDP based on foreign exports | | |
| (SE.3.2) Attractiveness for a city for foreign investment | 1) Develop network of industrial and commercial areas | | Including: business parks, specialized free zones of international distinction, a world class seaport, a major international airport, a cargo village, a modern highway network, state-of-the-art telecommunications, and reliable power and utilities. |
| | 2) International conferences and fairs | | International confrences and fairs aims at marketing and increasing our exports |

Table (12): Comments on key indicators for smart people

| KEY INDICATORS | DEFINITION/ DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SP.1.1) Primary and secondry Education | 1) % of students completing Primary Education ISO37120/6.2 | | 100% of students at this school-aged population should complete primary education |
| (SP.1.2) Student teacher ratio | 1) Primary education student to teacher ratio ISO37120/6.3 | | A high trend is a positive indication |
| (SP.1.3) College Education | 1) College education (number of higher education degree for 100,000 | | This includes all post -secondary education the city should build more vocational schools and try to change the culture of accepting the vocational schools as higher education |
| (SP.1.4) Adult literacy | 1) Adult literacy rate | | The percentage of population aged 15 years and over who can both read and write, a higher trend and values is considered positive to be able to use smart ICT applications |
| (SP.2.1) Student ICT classroom access | 1) % of students with classroom access to ICT facilities | | ICT facilities could include those with internet connectivity, Computer labs, digital learning, etc. |
| | 2) Smart phones penetration (% of residents with smartphones access) | | A higher trend and values is considered positive. The ministry of education should launch an online portal that supports the educational experience for both the teachers and the students. Through the portal, all students will have equal access to all educational resources, learning is made more interactive through videos, animation, simulations and games and online quizzes. |

| KEY INDICATORS | DEFINITION/ DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SP.2.2) Civic Engagement | 1) Civic engagement (% of civic engagement activities offered by municipality last year) | | The main strategy objectives of smart people are to enable people to interact with service providers and participate in civil society and civic engagement activities offered by the municipalities with ease, facilitate life learning experience of youth and elderly to accommodate technology advancement in provided services by the government, the smart people initiative aims to build capacity of people to interact with public and private service providers |
| (SP.3.2) Creative Industry | 1) Creative Industry Jobs | | Enable start-ups and innovation hubs to empower big data and analytics technologies, and next-generation sensor. Enabling these technologies will attract people from around the world to take advantage of city infrastructure and display their innovations |

Table (13): Comments on key indicators for smart Environment

| KEY INDICATORS | DEFINITION/ DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SE.1.1) Monitoring Energy | 1) Development of a platform to monitor energy consumption footprint (kWh/m2) in buildings Total residential Energy use per capita in KWH /year ISO 37120 /7.1 | | Advance the electric grid with better management of energy by using sensors and meters to measure consumption at peak hours and allow for remote monitoring and regular check of leakage. |
| | 2) Total Public building energy use per Capita in KWH/Year ISO37120/7.3 | | Buildings can account for 40% of GHG emissions, energy efficiency and energy conserve in buildings can reduce GHG significantly |
| (SE.1.2) Renewable Energy | 1) The percentage of energy driven from renewable energy sources in kwh/Yr as a share of total energy consumption ISO 37120 /7.4 | | Advanced technology applications for renewable energy solutions should be integrated into our urban fabric and be interactive with local residents on a physical and digital level. The government should present a solar system model to the residents to be implemented by all house owners and provide incentives for implementations that allow home owners to claim a tax credit for qualified expenditures related to the installation of a solar PV system. |
| (SE.1.3) Electric Energy | 1) % of city population with authorized electric energy ISO37120/7.2 | | See E government |
| (SE.1.4) Set Targets | 1) Set targets for clean energy power capacity via 25% 2020 and 75% by 2030 | | The government should continue implementing renewable energy solutions for business and commercial buildings and set targets for clean energy power capacity to be reached by specific dates opting for continuous increase of those targets. |
| (SE.2.1) Waste Management | 1) Waste management (% of solid waste recycled ISO37120/16.2) & total collected solid waste /capita in Kg ISO 37120/16.3 | | Smart environment are to promote more sustainable and resilient resources management through a focus on “reduce, reuse, recycle and cradle to cradle approach” in an effort to maximize landfill diversion and achieving efficiency in the overall waste management process |

| KEY INDICATORS | DEFINITION/ DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SE.2.2) Water Management | 1) % of city population with access to improved Sanitation ISO37120/21.3 | | |
| | 2) % of city population with potable water supply system ISO37120/21.1 | | |
| | 3) Total domestic water consumption /capita litres/day ISO 37120 /21.4 | | |
| | 4) % of city water receiving primary, secondary, tretiary treatment ISO37120 ISO 37120 20.3/20.4/20.5 | | Water pollution can be decreased to minimum with adequate investment in water treatment |
| | 5) % of commercial buildings with smart water fittings | | An increase is a positive trend |
| (SE.3.1) Air Quality and carbon footprint | 1) (Greenhouse gas emissions measured in ton/capita 5.5 Urban stakeholders should focus their efforts on reducing the carbon footprint of their city (in line with the COP-21 targets and SDG13) Fine Particulate Matter (PM2.5) And particulate matter (PM10) | | Sustainable urban planning through continuous measuring of greenhouse gas emissions measured in metric /ton. Urban stakeholders should focus their efforts on reducing the carbon footprint of their city (in line with the COP-21 targets and SDG13) and measure Fine Particulate Matter (PM2.5) And particulate matter (PM10) |
| (SE.3.2) Green area | 1) Green area /100,000 in m2 ISO 37120 /19.6 | | The planning idea of Administrative Capital consist on creating natural oasis, valid for the development, that links between them green axes to emphasize the concept of a green city, while taking into account the nature and the topography of the site. |

| KEY INDICATORS | DEFINITION/ DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SE.3.3) Climate resilience | 1) Climate resilience Planning Density | | Building a resilient city by designing a framework for the adaptation required to meet challenges presented by climate change and sea level rise and effect of storms and rainfall, capturing each drop of water by creating natural oasis valid for the development and taking advantage of storm water drain. The Concept of design of administrative Capital is incorporating climate resilience |
| (SE.3.4) Smart buildings | 1) Promoting green and innovative building Systems in construction and buildings (vernacular Architecture, BIM, and applying new technologies like self-healing concrete and 3D printing, ) | | Integrating a national green rating system and building Information management (BIM) in all levels of design and construction.<br>Experiment with unconventional building materials, Biocompatible materials with circular cradle to cradle lifecycle and new methods of construction and new technologies like self -healing concrete and 3D printing can challenge and improve the way we build smart sustainable buildings<br>Smart sustainable cities does not have to be high rise buildings with all glass façade, we can still apply smart systems to vernacular architecture and sustainable designs like Hassan Fathy designs |

Table (14): Comments on key Indicators for Smart Living

| KEY INDICATORS | DEFINITION/ DESCRIPTION | | COMMENTS |
|---|---|---|---|
| (SL.1.1) Budget Allocated to Culture | % of municipal budget allocated to culture | | Increase the percentage of municipal budget allocated to culture and recreation facilities that are important to maintain the health of city inhabitants |
| (SL.1.2) Gini Index | Gini Index of zero expresses perfect equality | | |
| (SL.1.3) Quality of life(Housing) | Quality of life ranking | | |
| | Education facilities | | |
| | Housing quality | | |
| | Social cohesion | | |
| | Touristic attractivity | | |
| (SL.2.1) Crime | Crime (number of crime rate for 100,000 population 14.5) | | |
| (SL.2.2) Crime prevention | Smart crime prevention | | Smart police Applications of ICT and AI (artificial intelegence) |
| | Number of police officers for 100,000 population | | |
| (SL.3.1) Single Unified Health History | Single health history (% of residents with single unified health history facilitating patients and health provider access to complete medical record) | | Electronic health records |
| (SL.3.2) Health Services | Number of inpatient hospital beds /100,000 | | Making our hospitals services smart and increasing the number of beds for each 100,000 patient in hospitals with smart features and services which are enabled by technology<br>Apply ICT technologies and IoT to track health and remote monitoring and fitness especially for the elderly |
| | Number of physicians for 100,000 population | | The availability of trained physcians is an important indicator of the strength of health system |
| (SL.3.3) Life Expectancy | Average life Expectancy | | An improving trend and higher rates of high expectancy at birth, which is the number of years a new born is expected to live is considered positive |
| (SL.3.4) Recreation | Square meter of public outdoor and indoor recreation facilities | | |

### 5.3 Recommendations for Administrative Capital

**Action plan for Smart Sustainable New Administrative Capital**

- Launch Smart Sustainable Administrative Capital Initiative that complies with the city vision and long term development. This will bring together teams working on various aspects of Smart Nation and Digital Government policy Creating a partnership with government agencies, industry and citizens to apply digital and smart technology that will enhance quality of life and create a vibrant eco-system promoting more effective resource management.
- Create an office to trace the journey of the city-state since the adoption of its Smart Sustainable City initiative till implementation and monitor the city ongoing performance *(Smart Sustainable New Administrative Capital Office)* in the Prime Minister's Office will play a key role in orchestrating multi-agency effort to achieve smart sustainable administrative capital. Figure 13

**In the Prime Minister's Office**

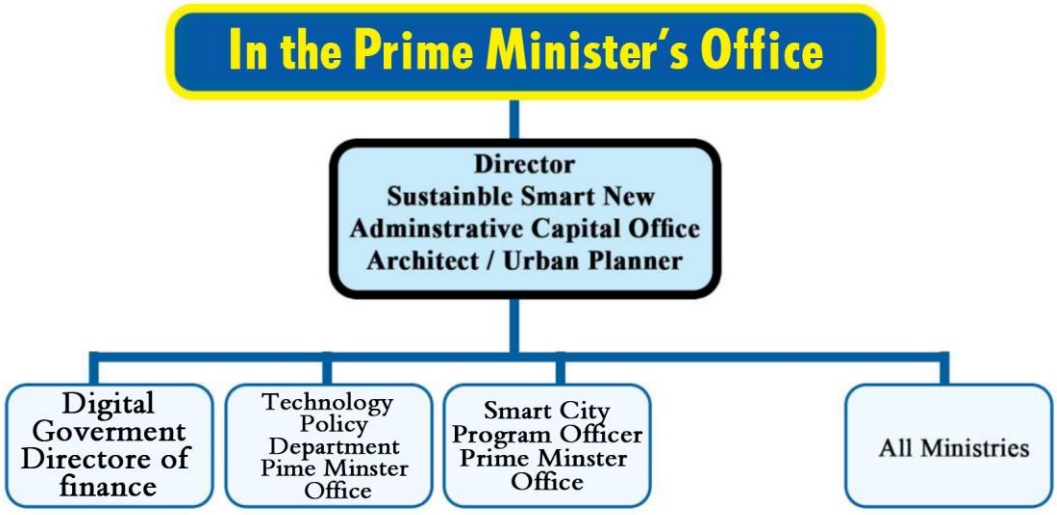


Figure (13): Organization chart for Sustainable Smart New Capital City Office

(Developed by the author)

- Explore and link the various smart city activities adopted under the Smart city initiative, with the Key Performance Indicators dimensions presented in this study, offering a deeper understanding of Egypt's efforts in each of these domains as presented in section 5.2 Assessment Scheme

- Set Goals to be achieved by fixed dates and provide a description of New Administrative Capital's Sustainable Smart City Initiative, goals and guidelines.
- Measure progress of the goals. The proposed framework is also intended to be used for monitoring the city's ongoing performance with respect to its smart city goals.
- Launch more ICT-based applications to stimulate public interest in this area
- The country governance system should facilitate the process of adopting smart city plans and allows the public initiatives to be acted upon as promptly as possible

# CHAPTER 6: SUMMARY, CONCLUSIONS and RECOMENDATIONS

## 6.1 Summary

The growing economic, social and environmental importance of cities has led to a global wave of urban development projects. The Smart City is part of this wave, and had been defined in this study. When the United Nations (UN) met in Quito 2016 to discuss Urban Sustainability during the Habitat III conference, one profound new policy direction was that smart cities entered the scene as a promising paradigm for a transition towards both urban resilience and urban sustainability (UN-Habitat, 2016,)

### 6.1.1 The goals of the study

- Adopt a definition of the Smart Sustainable City Concept and to understand how it can contribute to achieve urban development priorities, how the opportunities created by new technologies challenge the way in which we conceive our cities, live in them and manage them.
- Provide a foundation for developing a framework for planning and design of a Smart Sustainable City based on rigorous criteria and sub-criteria. the criteria have been selected according to official documents of international standards via ISO37120 and theInternational Telecommunication Union Focus Group of Smart Sustainable Cities (ITU-T-FGSSC),which builds on the importance of standardization in facilitating knowledge sharing and achieving the appropriate guidelines for implementation.
- The result of the study can be used to generate a framework and recommendations that has been tailored for urban planners, owners, operators and occupiers, to successfully and cost effectively adopt sustainable smart solutions as they plan, design, construct, and manage future cities.
- This framework can also be used to assess the smart sustainable urban development of a new or already built cities in their transformation into smart sustainable cities. Hence this study has been used in assessing new Administrative Capital of Egypt, one of the most ambitious and important urban development projects at present in Egypt.

### 6.1.2 Potential users for the presented frame work:

- City Officials to understand the advancement in ICT and how its applications can be used in making cities smarter and more sustainable. This can help City officials and municipal administrations develop strategies to achieve progress.
- City residents and non-profit organizations – enabling them to understand the development and progress of SSC.
- City service providers, operation and maintenance organizations to help them share information and applications of ICT for better performance and advancement of services in the city.
- Evaluation and ranking agencies, including academia – supporting them in selection of relevant key performance indicators for assessing the contribution from ICT in the development of SSC.

### 6.1.3 Smart City Framework Development Plan adopted by AUC and Yale University

**1. Smart Mobility**

**Multimodal Transport System**

- A mobility system that is safer and more convenient than the private car at much lower cost. The policy goal of Smart mobility is to provide commuters with a choice of multimodal transport system: This could include underground metro, bus rabbit transfer, trains and speed trains, that could maximize the use of public transportation and reduce carbon emissions for cleaner city
- Enhancing journey planning through all-in-one transport mobile applications, real time information by transportation department on capacity, routes and locations and to detect any traffic events.
- Deployment of sensors at intersection, traffic lights, express roads for traffic management and decrease of congestion
- International Easy and Efficient Travel with Smart Airport
- Maximize the use of car assets through the use of car sharing and car pooling

- Innovate in traffic planning and design, building freight and utilities tunnel for autonomous vehicle, to transport freight leaving the way for pedestrian.

**ICT Infrastructure**

- Develop ICT spatial data infrastructure to support government and private organization with information infrastructure which is essential to support smart city applications
- Develop an application architecture framework and implement a central platform for different government services. A new integrated cloud infrastructure needs to be developed to accommodate future smart city applications
- Implement 4G and 5G technology which supports a broad array of IoT Technology characterized by high speed mobile transmission and mobility, the ultimate goal is to have net access all day all time for everyone through increasing free hot spot areas especially at public areas, libraries and commercial centers
- Launch more ICT-based applications to stimulate public interest in the area of Smart Sustainable City
- Review and implement best practices for cyber security, raising awareness and educating users on best practices, continuously updating guidelines and strategy for IoT security

**Sustainable**

- Autonomous vehicle technology and digital navigation tools can give rise to a next-generation.
- Non- mechanical transportation can enhance pedestrian, cycling experience and complement their use with the public transportation system. Cyclists should be able to connect their bicycle routes to other areas of the city by leveraging public transit.

2. **Smart Government**

**Online Services**

- E-government aims at facilitating the relationships between people and their government through a unified shared platform and advanced electronic and mobile services. The ultimate goal is to make public services delivery more effective, accessible and responsive to people's needs.
- It also aims at increasing participation in decision-making and making public institutions more transparent and accountable.
- Procurement transactions for the government (bids, requests for proposal (RFP), invoices, payments) can be performed through electronic platforms which can facilitate efficiency in government operations and allow for a wider base of suppliers to access potential government business.

**Infrastructure**

- Provide high level of basic non ICT infrastructure: water and sanitation, electricity, waste management, transportation and roads
- Provide sensors to monitor consumption and services

**Open Governance**

- Use Central Data management platform to access growth and sustainability
- Initiate smart city initiative and set Smart City Program Office to coordinate efforts between private, public sector and civil to achieve smart sustainable city strategies and guidelines.

3. **Smart Economy**

**Entrepreneurship and Innovation**

- Develop economic plans and policies, identify and support the growth of strategic sectors, and provide services to domestic and international investors and businesses**.**
- Develop network of industrial and commercial areas including: business parks, specialized free zones of international distinction, a world class seaport, a

major international airport, a cargo village, a modern highway network, state-of-the-art telecommunications, and reliable power and utilities

- Enable start-ups and innovation hubs to empower big data and analytics technologies, and next-generation sensor. Enabling these technologies will attract people from around the world to take advantage of city infrastructure and display their innovations.
- Create an Environment in which new ideas can be tested through start-ups, research centers and partnerships with universities. Expand research and development platform through building Innovation and technology parks as Silicon valley

**International Embeddedness**

- Innovation hubs can be used to develop new technologies that will attract investors to take advantage of this innovative environment.
- Complement the existing strength of the financial sector with FinTech development
- Encourage the private sector to invest in Public sector

**Productivity and Employment**

- Employment Rate

Higher employment rates are positive indications

4. **Smart Environment**

**Energy**

- Advance the electric grid with better management of energy by using sensors and meters to measure consumption at peak hours and allow for remote monitoring and regular check of leakage.
- Advanced technology applications for renewable energy solutions should be integrated into our urban fabric and be interactive with local residents on a physical and digital level. The government should present a solar system model to the residents to be implemented by all house owners and provide

incentives for implementations that allow home owners to claim a tax credit for qualified expenditures related to the installation of a solar PV system.

- The government should continue implementing renewable energy solutions for business and commercial buildings and set targets for clean energy power capacity to be reached by specific dates opting for continuous increase of those targets.

**Sustainable and resilient resource management**

- Smart environment are to promote more sustainable and resilient resources management through a focus on "reduce, reuse, recycle and cradle to cradle approach" in an effort to maximize landfill diversion and achieving efficiency in the overall waste management process.
- Building a resilient city by designing a framework for the adaptation required to meet challenges presented by climate change and sea level rise and effect of storms and rainfall, capturing each drop of water by creating natural oasis valid for the development and taking advantage of storm water drain.
- Boost telecommunication signals at crisis time building resilience of the city at flood and at drainage points with early alarm sensors placed at drainage point.
- Design buildings with smart water fittings and reusing of grey water for landscape irrigation.

**Sustainable Urban Planning**

- Sustainable urban planning through continuous measuring of greenhouse gas emissions measured in metric /ton. Urban stakeholders should focus their efforts on reducing the carbon footprint of their city (in line with the COP-21 targets and SDG13) and measure Fine Particulate Matter (PM2.5) And particulate matter (PM10)
- Promote green and intelligent buildings in construction and integrating a national green rating system and building Information management (BIM) in all levels of design and construction.
- Experiment with unconventional building materials, Biocompatible materials with circular cradle to cradle lifecycle and new methods of construction and

new technologies like self -healing concrete and 3D printing can challenge and improve the way we build smart sustainable buildings

- Smart sustainable cities does not have to be high rise buildings with all glass façade, we can still apply smart systems to vernacular architecture and sustainable designs like Hassan Fathy designs

5. **Smart Living**

**Culture and Wellbeing**

- The smart living initiative seeks to enhance the overall living experience of the people. This includes better living experience across age groups, improved public healthcare services, better life and better wellbeing for our citizens.
- Achieve a Geni- Index of Zero which expresses equality
- We live in a divided city, where the number of upscale housing and disadvantaged neighborhoods continues to rise and the middle low income neighborhoods are disappearing. The government has to think of building more affordable houses with all basic infrastructure implemented.

**Health**

- Provide one single electronic health record for each patient that can be accessed by all health providers through a shared platform, which contains the most update information for the patient. Additional information could be uploaded as immunization, imaging results, billing results etc.
- Making our hospitals services smart and increasing the number of beds for each 100,000 patient in hospitals with smart features and services which are enabled by technology
- Apply ICT technologies and IoT to track health and remote monitoring and fitness especially for the elderly
- An improving trend and higher rates of high expectancy at birth, which is the number of years a new born is expected to live is considered positive
- Increase the percentage of municipal budget allocated to culture and recreation facilities that are important to maintain the health of city inhabitants

**Safety**

- Decrease the number of crime rates for 100,000 inhabitant through smart crime prevention and smart technological applications for security.

## 6. Smart People

The main strategy objectives of smart people are to enable people to interact with service providers and participate in civil society and civic engagement activities offered by the municipalities with ease, facilitate life learning experience of youth and elderly to accommodate technology advancement in provided services by the government, the smart people initiative aims to build capacity of people to interact with public and private service providers

**Education**

1. The number of people continuing primary education should reach 100% of total population at this educational age and increase primary education student to teacher ratio with a target to achieve zero adult illiteracy rates.
2. Increasing the number of people finishing Secondary education and technical education
3. Implement ICT in the national educational system to build capacity of teachers and integrate ICT in the educational process to support the educational experience of students.

**Inclusion**

4. The ministry of education should launch an online portal that supports the educational experience for both the teachers and the students. Through the portal, all students will have equal access to all educational resources, learning is made more interactive through videos, animation, simulations and games and online quizzes.
5. Materials available on the portal should be designed in compliance with the industry needs and real world challenges. Every student will have equal access to quality online learning resources. With respect to health
6. Increasing confidence of the community in applying new smart city practices through continuous training, learning seminars and training materials

7. Develop ICT and open data to help government to engage with citizens and the public to have access to information on government services and performance

## 6.2 CONCLUSIONS

- We have the opportunity how urban planning can redefine how we build our cities in the 21 first century
- The current large gap between smart city and sustainable city frameworks implies that there is a need for developing their frameworks further.
- The key indicators developed in this study, provide cities at the planning and design stage with a credible framework when adopted at this stage and after construction. Previous models in the literature were created to help cities transform into smart cities after being built.
- This study is more oriented towards achieving aspects of urban life with the ICT as a mean for development. Previous models developed frameworks and key indicators that were more oriented towards enhancing ICT.
- Literature illustrates a difference in the key dimensions, adopted by different models, the key dimensions created by the ITU-T FG-SSC is the one adopted in this study, as it is more oriented towards achieving aspects of Urban life to create smart sustainable cities after extensive analysis of the literature
- Building up on the key dimension model that was developed by the ITU-TFGSSC emphasizes the importance of standardization in facilitating knowledge sharing and achieving the appropriate guidelines for implementation
- Filling a gap in research, this study developed sub-dimensions and key indicators for the key dimensions model that was created by ITU-TFGSSC, as sub-dimensions and key indicators were not developed for this model before
- Debates about environmental challenges are often hindered by lack of problem definition, and ill-defined solutions. Gathering data into the recommended proposed framework helps to resolve these difficulties

- City assessment tools can be used as support for decision making in urban development as they provide assessment methodolgies for cities to show progress towards defined targets.
- Providing advanced ICT services and IoT for people in a city is not enough. Building capacity of people through education, training and culture is essential for the people to be able to accommodate and commprehend advancement in Technology
- The growth of cities in the twenty first century should depend on sustainable cities approach that utilizes Information and Communication Technology (ICT) and smart technology that will bring about radical redefinition of work, services and mobility

## 6.3. RECOMMENDATIONS

### 6.3.1 General Recommendations

- A city implementing Smart Sustainable City Concept should launch a Smart Sustainable City Initiative, integrated as a culture among all sectors, private, public and Civil
- Assign a Smart Sustainable City Office (SSCO) to be in-charge of setting goals and monitoring progress preferably to be founded under the prime minister office, to have full authority in coordinating between different agencies to achieve the ultimate goal of the Smart Sustainable City
- Announce a pilot area of the city to implement smart indicators presented in the framework suggested by this research, to illustrate how the proposed framework might take physical form on a given site and real urban condition offering a deeper understanding of Egypt's efforts in each of these domains as presented in section 5.2 Assessment Scheme, after success implement it in all the city
- Set Goals to be achieved by fixed dates and provide a description of New Administrative Capital's Sustainable Smart City Initiative, goals and guidelines.

- Measure progress of the goals. The proposed framework is also intended to be used for monitoring the city's ongoing performance with respect to its smart city goals.

### 6.3.2 Recommendations for the Industry

- The industry should take advantage of all opportunities embedded in the Smart Sustainable City Concept
- The industry should create an environment in which new ideas can be tested through start-ups, research centers and partnerships with universities.
- Expand research and development platform through building Innovation and technology parks as Silicon valley
- Establish a living laboratory for urban planning and civic technology experimentation at different pilot areas
- Construction Companies should implement different and innovative methods of Environmental, construction and ICT. Innovative physical solutions under real urban conditions. A Smart building does not have to be high rise with glass façade.
- The city should maximize the use of mobility assets through the use of sharing concept, example carpooling, bicycle sharing and Autonomous car.
- The ultimate goal is to ban the use of private cars or decrease it to minimum. The industry should implement new solutions and innovative ideas to achieve those goals.
- Advanced technology applications for renewable energy solutions should be integrated into our urban fabric and be interactive with local residents on a physical and digital level.
- The industry should present a solar system model to the residents to be implemented by all house owners and the government should provide incentives for implementations that allow home owners to claim a tax credit for qualified expenditures related to the installation of a solar PV system.

### 6.3.3 Recommendations for Future Work

- The methodology for developing the model is a qualitative comparative analysis of the literature that was generated to gather data and all aspects of smart sustainable city in a single framework that could be a base for developing future rating system for smart sustainable cities for future research

## 7: REFERENCES


1. 2030 Sustainable Development Goals, United Nations | High-level Political Forum on Sustainable Development | New York City | September 2015
2. Alawadhi, S., Aldama-Nalda, A., Chourabi, H., Gil-Garcia, J.R., Leung, S. , Mellouli, S., Nam, T., Pardo, T.A., Scholl, H.J., and Walker, S. "Building Understanding of Smart City Initiatives," Lecture Notes in Computer Science 7443 (2012) 40–53. [ Links ]
3. Allwinkle, S., Cruickshank, P.: Creating Smart-er Cities – An Overview. Journal of Urban Technology 18(2), 1-16 (2011) [ Links ]
4. Al-Nasrawi,Sukaina, Adams carl , El-Zaart, Ali, A Concepyual Multidimentional Model for Assessing Smart Sustainable JISTEM J.Inf.Syst. Technol. Manag. vol.12 no.3 São Paulo Sept./Dec. 2015
5. Barrionuevo, J.M,Berrone, P, and Ricart, J.E."Smart Cities, Sustainable Progress,"IESEInsight14(2012) 50–57 [ Links ]
6. Caragliu, A, Del Bo. C. & Nijkamp. P. (2011). Smart Cities in Europe. Journal of Urban Technology, 18(2), 65–82. DOI:10.1080/10630732.
7. Center on Governance. (2003). Smart Capital Evaluation Guidelines Report: Performance Measurement and Assessment of SmartCapital. Ottawa, Canada: University of Ottawa. Available at http://www.christopherwilson.ca/ papers/Guidelines_report_Feb2003.pdf.
8. Collection Methodology for Key Performance Indicators for Smart Sustainable Cities, United 4 all, ITU-T (2017)
9. Deakin, M., and Al Waer, H., "From Intelligent to Smart Cities,"Intelligent Buildings International3:3 (2011)140–152.
10. Dirks, S., Gurdgiev, C.and Keeling, M. Smarter Cities for Smarter Growth: How Cities Can Optimize Their Systems for the Talent-Based Economy (Somers, NY: IBM Global Business Services, 2010).
11. Economist Intelligence Unit (EIU) (2013). Hot spots 2025: Benchmarking the future competitiveness of cities.

12. Eger, J.M.,“Smart Growth, Smart Cities, and the Crisis at the Pump A Worldwide Phenomenon,”I-Ways 32: 1 (2009) 47 –53.
13. EIU (2010). Digital Economy Rankings, Beyond e-readiness. Economist Intelligence Unit (EIU), Economist Publications.
14. Forbes (2014). Smart Cities -- A $1.5 Trillion Market Opportunity.Forbes LLC. Web. Accessed, Retrieved from: http://www.forbes.com/sites/ sarwantsingh/ 2014/06/19/smart-cities-a-1-5-trillion-market-opportunity/
15. Gabrys, J.: Programming environments – environmentality and citizen sensing in the smart city. Environment and Planning D: Society and Space 32, 30-48 (2014)
16. Giffinger, R., & Gudrun, H. (2010). Smart cities ranking:Aneffective instrument for the positioning of cities?ACE: Architecture, City and Environment, 4(12), 7-25. Available at http://upcommons.upc.edu/ revistes/bitstream/2099/8550/7/ACE _12_SA_10.pdf.
17. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R.,Pichler-Milanovis, N., & Meijers, E. (2007). Smart Cities:Rankingof European Medium-Sized Cities. Vienna, Austria: Centre of Regional Science (SRF), Vienna University of Technology. Available athttp://www.smart-cities.eu/download /smart_cities_final _report.pdf.
18. Harrison, C. & Donnelly, I. (2011). A Theory of Smart Cities. Proceedings of the 55th Annual Meeting of the ISSS-2011. Hull, UK.
19. Hamdy, Ahmad & Abdelkader, Morad & Stait, Mohamed & Samy, Sara & Khalifa, Sara. (2018). Defining the Characteristics of Prefabricated Architecture as an Alternative Sustainable Construction Approach.
20. IBM (2011). IBM’s Smarter Cities Challenge: Philadelphia Report. Armonk, NY.
21. IEEE SC (2014). IEEE Smart Cities (SC). http://smartcities.ieee.org/. (Accessed on December 20 2014).
22. IEEE(2015) http://smartcities.ieee.org/news-bulletin/march-2015/ editorial. html, accessed: Sunday, 16 August 2015 at 11:00 pm.
23. Implementing ITU-T International Standards to Shape Smart Sustainable Cities, The Case of Singapore, Information Media Development Authority (2017)

24. International Telecommunication Union (ITU). 2014. Measuring the Information Societyeport. http://www.itu.int/en/ITU-D/Statistics/Documents/publications/mis2014/MIS2014_without_Annex_4.pdf(Accessed on December 28 2014)
25. International Telecommunication Union (ITU). http://www.itu.int/en/ITU-D/Pages/default.aspx. (Accessed on January 04, 2015).
26. ITU-T FG-SSC (2014). Technical Report on Smart Sustainable Cities: An analysis of definitions. United Nations, International Telecommunication Union (ITU-T), Focus Group on Smart Sustainable Cities (FG-SSC).
27. Khalifa, Sara & Abdelkader, Morad & Eissa, Mostafa & M Hamdy, Ahmad. (2018). Obstacles of Application of Green Pyramid Rating System (GPRS) on Local Projects in Egypt. International Conference on Sustainability, Green Buildings, Environmental Engineering & Renewable Energy (SGER 2018), At Kuala Lumpur, Malaysia
28. Kanter R.M., and Litow, S.S., Informed and interconnected: A manifesto for smarter cities, Harvard Business School General Management Unit, 09-141, 2009.
29. Klein, C., & Kaefer, G. (2008). From smart homes to smart cities: Opportunities and challenges from an industrial perspective. InProceedings of the 8th International Conference, NEW2AN and 1st Russian Conference on SmartSpaces, ruSMART 2008 (St. Petersburg, Russia, Sep 3-5).
30. Hamdy, Ahmad & Abdelkader, Morad & Stait, Mohamed & Samy, Sara & Khalifa, Sara. (2018). Defining the Characteristics of Prefabricated Architecture as an Alternative Sustainable Construction Approach. springerlink. com/content/d053p7u7g42u573p/.
31. Kourtit, K. & Nijkamp, P. (2012). Smart Cities in the Innovation Age. Innovation: The European Journal of Social Science Research, 25(2), 93–95.
32. Kourtit, P. Nijkamp, and D. Arribas, “Smart Cities in Perspective – A Comparative European Study by Means of Self-organizing Maps,”Innovation: The European Journal of Social Science Research25:2(2012)229–246..
33. KPMG (2012). 2012 Change Readiness Index. KPMG International Cooperative and Overseas Development Institute (ODI).

34. Lombardi, P., Giordano, S., Farouh, H., and Yousef W., “Modelling the Smart City Performance,”Inno-vation: The European Journal of Social Science Research 25:2(2012)137–149.

35. Mahizhnan, A., “Smart Cities: The Singapore Case,”Cities16:1(1999)13–18.

36. Mori K., & Christodoulou A. (2012). “Review of Sustainability Indices and Indicators: Towards a New City Sustainability Index (CSI),” Environmental Impact Assessment Review 32: 1 (2012) 94–106.

37. Moser, M. A. (2001). What is smart about the smart communities movement? EJournal, 10/11(1). Available at http://www.ucalgary.ca/ejournal/

38. Nam, T., & Pardo. T. (2011). Conceptualizing Smart City with Dimensions of Technology, People, and Institutions. Proceedings of the 12th Annual International Digital Government Research Conference, pp. 282-291.

39. Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G. & Scorrano, F. (2014). Current trends in Smart City initiatives – Some stylised facts. Cities 38, 25–36.

40. OECD Better Life Index. http://www.oecdbetterlifeindex.org/. (Accessed on January 02 2015)

41. Retrieved from smartercitieschallenge.org/city_philadelphia_pa.html.

42. Sidewalk Toronto’s fellows Report, 2017 (www.sidewalktoronto.ca)

43. Spangler, W. S., Kreulen, J. T., Chen, Y., Proctor, L., Alba, A., Lelescu, A., & Behal, A. (2010). A smarter process for sensing the information space. IBM Journal of Research and Development,54(4). DOI: 10.1147/JRD.2010.2050541.

44. Sustainable Development Communities –Indicators for city Services and quality of life , ISO 37210 (2014)

45. The Global Open Initiative. http://globalopendatainitiative.org/

46. Thuzar, M.,“Urbanization in South East Asia: Developing Smart Cities for the Future?,”RegionalOutlook (2011)96–100.

47. Townsend, A. (2013). Smart Cities – Big Data, Civic Hackers and the Quest for a new Utopia. Norton & Company, USA: New York.

48. Turcu,C. “Re-thinking Sustainability Indicators: Local Perspectives of Urban Sustainability,” Journal of Environmental Planning and Management 56: 5 (2013) 695–719.

49. UNDESA (2012). World Urbanization Prospects, the 2011 Revision: Highlights. United Nations Department of Economic and Social Affairs (UNDESA), United Nations Populations (ST/ESA/SER.A/317)

50. UNDESA (2014). United Nations E-Government Survey. United Nations Department of Economic and Social Affairs (UNDESA).

51. United Nations (2015b). Habitat III issue papers, 21 – Smart cities. V. 2.0 (31 May 2015) ( p. 45) , issued in New York, USA, by UN task team on Habitat III, a task force of UN agencies and programs for the New Urban Agenda, prepared for Habitat III United Nations Conference on Housing and Sustainable Urban Development to take place in Quito, Ecuador, 17–20 October 2016.

52. WEF (2014). The Global Information Technology Report, Rewards and Risks of Big Data. World Economic Forum (WEF) and INSEAD, Geneva, ISBN-13: 978-92-95044-63-0.

53. WIPO (2014). The Global Innovation Index, the Human Factor in Innovation. World Intellectual Property Organization (WIPO), Geneva, ISSN 2263-3693.

54. World Commission on Environment and Development (WCED): Our common future. Oxford Univ. Press, Oxford (1987)

55. Yovanof, G. S., & Hazapis, G. N. (2009). An architectural framework and enabling wireless technologies for digital cities & intelligent urban environments. Wireless Personal Communications, 49(3), 445-463. Available at: http://www.springerlink.com/conte

**APPENDIX A**

**https://www.itu.int/en/publications/Documents/tsb/2017-U4SSC-Collection-Methodology/files/downloads/421318-CollectionMethodologyforKPIfoSSC-2017.pdf**

**APPENDIX B**

**Case Study Dubai https://www.itu.int/en/mediacentre/Pages/2016-PR61.aspx**