"Smart Dubai, the happiest city on Earth"

Implementing ITU-T International Standards to Shape Smart Sustainable Cities:

The Case of Dubai

Acknowledgements

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This case study is intended for informational purposes only. The results and interim findings presented in this case study are a work-in-progress as the KPIs (Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602) implemented in Dubai during the first phase of the pilot project are being refined to improve the applicability of these KPIs to all cities.

The revision of the KPIs may alter their scope and definition as well as the required data collection process. Therefore, readers are cautioned that the KPIs presented in this case study may not necessarily be entirely compatible with the subsequent KPIs published by ITU after the revision process.

The quote in the cover has been directly taken from the Smart Dubai initiative, which strives to make Dubai the "happiest city on Earth".
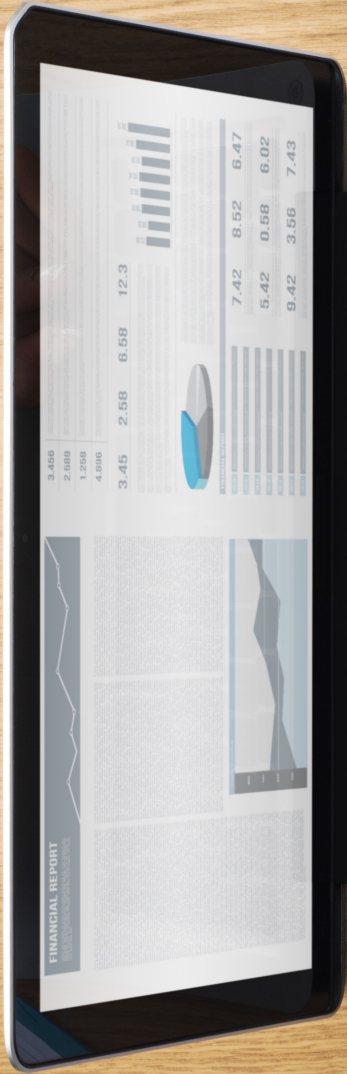
Abstract

This case study is the first of its kind, developed by ITU, detailing Dubai's ambitious and trailblazing journey towards becoming a smart city, a venture worthy of emulation by other aspiring smart cities around the world. Following ITU's and Smart Dubai's collaboration on Dubai's smart city endeavour, the ITU-T Recommendations Y.4901/L.1601 and ITU-T Y.4902/L.1602 were piloted in Dubai to determine their feasibility and to measure Dubai's level of success in its smart city venture. As we bid adieu to the first year of the pilot project, this case study reveals, inter alia, that the KPIs would need to be refined to enhance their applicability in Dubai and on a global scale. To assist aspiring smart sustainable cities in their journeys, this case study also derives best practices based on Dubai's current activities. It concludes with some useful suggestions for adoption by Dubai and ITU during the second year of the implementation of this pilot project.

Foreword

Dubai is a city that has transformed rapidly in the past several decades: emerging from a small trading village to an international business hub in the span of just 40 years. The Dubai government has been continually committed to adopting the latest technology innovations to deliver opportunities for enhanced quality of life for all citizens, residents and visitors to Dubai.

The Smart Dubai initiative was launched in March 2014 to unify and enhance existing ICT initiatives from the government; enable and deliver a citywide platform for the exchange of information and transaction of daily services; and work together between the public and private sector to share the benefits of a smart city, defined as the efficient use of resources; seamless service delivery; safely protected people and information; and impactful business and life experiences.
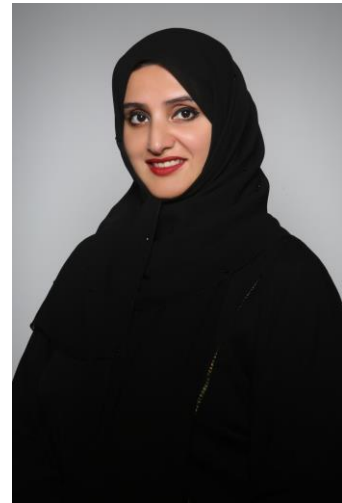
Carrying forward the commitment of our leadership, to prioritise resident and visitor experience in Dubai, our end goal has consistently been to positively impact people's happiness. The vision of Smart Dubai is to make Dubai the happiest city on Earth; and smart technology, with the resulting benefits of collaboration, time saving, efficiency and sustainability, provides the tools to achieve this.

But we do not undertake this transformation for ourselves alone. Smart Dubai aims to become a global leader among smart cities, in order to share our experiences and become a benchmark to smart city transformation for the emerging world.

Dubai is proud to be the first pilot partner to implement the ITU-standardised Key Performance Indicators (KPIs) for Smart Sustainable Cities. With the support of our strategic partners, we have tested 108 KPIs that became a global standard to smart city achievements, and we are sharing our experiences from this process with the world.

In the first year of the program, we have already seen a significant response to the ITU-Dubai pilot program, and leading cities including Valencia, Singapore, Buenos Aires, and Montevideo have signed up for similar pilot projects. Furthermore, recommendations from the first year of the pilot program led to establishment of the United for Smart Sustainable Cities (U4SSC), the first global initiative exclusively for smart sustainable cities.

For Dubai, the second year of the pilot program will be an opportunity to focus our efforts to delivering measurable impact for Dubai. Globally, we will continue our work with the ITU to bolster a new, rigorous standard for smart cities that prioritises access to opportunity, sustainability, and quality of life benefiting all global citizens.

I take this opportunity to congratulate all of our strategic partners, the members of the Smart Dubai team, and the ITU Focus Group on Smart Sustainable Cities, for their hard work and commitments which are evidenced in this report.

Thank you and we look forward to our continued collaboration.

Her Excellency Dr Aisha Bin Bishr
Director General, Smart Dubai

Our cities host the majority of the world's people. These cities are our main driver of economic output, and they are also our main source of energy consumption and greenhouse gas emissions. Cities will be a key battleground in our fight for environmental sustainability. This is very evident to decision-makers, with the development of Smart Sustainable Cities fast becoming a key policy point to administrations worldwide.

Smart Sustainable Cities will contribute to the achievement of Goal 11 of the UN Sustainable Development Goals: to "Make cities inclusive, safe, resilient and sustainable". And as part of the New Urban Agenda adopted by the UN Conference on Housing and Sustainable Urban Development (Habitat III), countries have committed to "adopting a smart-city approach that makes use of opportunities from digitalization, clean energy and technologies, as well as innovative transport technologies".

It is crucial that the ICT infrastructure of a Smart Sustainable City ensures openness and interoperability, and this can only be achieved with coordinated adherence to common standards.

ITU-T Study Group 20 develops international standards to enable the coordinated development of IoT technologies, including machine-to-machine communications and ubiquitous sensor networks. This work is supporting the emergence of a shared, integrated data ecosystem that will enable us to use data-driven insight to encourage sustainable urban development.

Our pilot project to implement the ITU-standardized Key Performance Indicators (KPIs) for Smart Sustainable Cities is a valuable complement to our technical work. This project will ensure that ITU's refinement of these indicators is undertaken on the basis of cities' experiences with their implementation.

Dubai was the world's first city to join this pilot project, and this case study is example of Dubai's will to share its smart-city experience with the international community. The next phase of ITU's collaboration with Dubai will aim to ensure that ITU's KPIs offer valuable assistance in measuring our progress towards the achievement of the SDGs and abiding by the guidelines set out by the New Urban Agenda.

ITU is also providing a neutral venue to discuss how policy innovation could drive the successful development of Smart Sustainable Cities.

This policy debate is hosted by the "United for Smart Sustainable Cities global initiative", a new ITU initiative undertaken in partnership with the United Nations Economic Commission for Europe. This initiative provides a platform to advocate for public policy to ensure that ICTs play a definitive role in building Smart Sustainable Cities. This initiative was launched in May this year and is already supported by 16 United Nations agencies.

Technical experts are invited to contact ITU to learn more about how you could participate in our standards work, and we would also be glad to explore how your city could become part of our KPI pilot project. Our U4SSC initiative welcomes participation from all decision-makers contributing to sustainable urban development, and we would be pleased to discuss with you how your organization could play a part in this important advocacy work.

Dr Chaesub Lee
Director, ITU Telecommunication Standardization Bureau

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Executive Summary

The International Telecommunication Union (ITU) has been at the forefront of fostering the development of Smart Sustainable Cities worldwide through its close involvement in multiple initiatives. The ITU Focus Group on Smart Sustainable Cities (FG-SSC) established the groundwork and enunciated the fundamentals for transforming the vision of cities through the systematic inclusion of information and communication technologies (ICTs) in the core of the sustainability considerations for smart cities.

During the time that FG-SSC was undertaking its work, Dubai and ITU signed a cooperation agreement in May 2015 whereby Dubai committed to become the first city to pilot the Key Performance Indicators (KPIs) related to city smartness and sustainability that were formulated by the FG-SSC. This example is one of the pioneering actions undertaken by Dubai, which is the second largest emirate of the United Arab Emirates, to reach their goal of becoming the happiest and smartest city in the world.

Following the work of FG-SSC and the ITU-T Study Group 5 on "Environment Climate Change and circular economy", a new ITU-T Study Group 20 entitled "Internet of things and Smart Cities and Communities" was created in June 2015. This work is being done in coordination with other study groups and in alignment with the global sustainability agenda articulated in the United Nations Sustainable Development Goals.

In this endeavour, ITU highlighted the actions needed to create conducive conditions to make modern cities better places to live and to do business in, while at the same time reducing energy use, carbon emissions and congestion.

As a result of the work of the FG-SSC (mentioned above) and with the knowledge that Dubai was prepared to initiate a pilot project, ITU-T completed a set of Key Performance Indicators (KPIs) to assess the impact of the use of ICTs in the sustainability of smart cities. These KPIs are now included in Recommendations 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, *Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities*.

The pilot project undertaken by Dubai (based on the cooperation agreement mentioned above), tested the KPIs included in both Recommendations and also provided inputs to ITU-T Study Group 5 on how ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 could be improved. The first phase also included a KPI assessment and verification process conducted during the last quarter of 2015 to allow for an accurate indication of the current performance of Dubai.

While the pilot project was underway in Dubai, the UN Sustainable Development Goals (SDGs) were approved and as such the process to improve ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 was modified to include a goal of supporting the UN SDGs.

With the knowledge gained through the Dubai pilot project, in July 2016, ITU in conjunction with UNECE launched the United for Smart Sustainable Cities Initiative (U4SSC) in partnership with 14 other UN Agencies and Programmes. One of the goals of the initiative is to update the KPIs contained in ITU-T Y.4901/L.1601, ITU-T Y.4902/L.1602 and ITU-T Y.4903/L.1603 to foster support the realization of the UN SDGs and the development of a Smart Sustainable City Index to which the improved KPIs will be a key input.

The pilot project undertaken by Dubai demonstrates beyond doubt their steadfast resolve to speedily join the ranks of internationally recognized smart cities and lead the global process to transform the current urban environments. The experiences related to the first year of Dubai pilot project are reflected in this case study. This case study will provide other smart city practitioners with an in-depth view of the processes implemented during this pilot project,

which will eventually allow for the benchmarking of feasible and efficient smart city practices for the future through a Smart Sustainable City Index.

Dubai's commendable willingness to engage in the process of data collection, data verification, and feedback has provided significant inputs to review and improve, where required, Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. This study is focussed on learning from the Dubai experience, based on a comprehensive understanding of the city's transition to a smart city, obtained through extensive description and analysis of that transition taken as a whole and in its context.

In effect, this case study highlights the crucial importance of the Dubai smart city pilot project to the future implementation of the ITU KPIs on a global scale. Some of the main challenges and opportunities in reporting the KPIs will also be examined in this case study for the benefit of aspiring smart cities. This case study also emphasizes on the importance of this pilot project in the development of a "Global Smart Sustainable Cities Index" together with other 15 United Nations agencies and programmes.

Section 1 provides the scope of the study based on the first year of Dubai's smart city pilot project with ITU. Some of the aspects covered by this case study are Dubai's smart city vision, Dubai's smart city activities, identification of the improvement opportunities in processes conducted within the pilot project and providing suggestions to aspiring smart cities based on the experience in Dubai.

Section 2 explores the history of ITU's smart sustainable city activities, including the origin of associated ITU Recommendations. This Section also provides a brief overview of the ITU dimensions that are used to categorize the key performance indicators related to Smart sustainable cities.

This is followed by Section 3 which focuses on the main elements of the Dubai case study. Before examining Dubai's smart city voyage, this section begins with a concise introduction of Dubai's geography and certain important demographic facts. The section describes Dubai's smart city vision, strategy, and governance model for becoming a smart sustainable city and the happiest city in the world. This promising setting makes Dubai an exemplary location to test the KPIs included in Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. The *Smart Dubai* initiative's extensive application of ICTs makes the city an ideal site for the use of the indicators and their subsequent refinement. The broad scope of the *Smart Dubai* initiative makes for an excellent field trial of ITU's key performance indicators as one has the opportunity to trace the efficacy of a wide range of ICT applications from inception to maturity.

Dubai has carried out the process with the support of several entities under the leadership of Smart Dubai Office, which is the body in charge of driving the smart city agenda in the Emirate. The role of this entity has been crucial in guaranteeing the success of this process, and in identifying opportunities to improve the processes over the following years.

Section 3 subsequently provides a description of the methodology used to develop the case study, including Dubai's data collection process and the reporting process adopted for the KPIs. The methodology contained in this section also focuses on the assessment, evaluation, and verification process implemented throughout the pilot project. This Section also provides the analysis of the first year of KPI data collection along with the assessment and verification conducted in the City.

Section 3 then summarizes the various initiatives that Dubai has implemented to become a smart sustainable city across the different city dimensions evaluated. These dimensions include: ICTs, Environmental Sustainability, Productivity, Quality of Life, Equity and Social Inclusion, and Physical Infrastructure.

With reference to the ICT Dimension, it is important to highlight Dubai's effort in the deployment of advanced technologies in the Emirate. It is worth mentioning that Smart Dubai is coordinating with the UAE Telecommunication Regulatory Authority (TRA) to promote and assess in a standardized way, the use of ICTs in the city to guarantee its sustainable growth in the future. Based on the lessons learned from Dubai's experience, the cities wishing to go the smart and sustainable way, should enhance the management and control of the sustainability risks associated with the intensive use of ICTs, especially Electromagnetic Fields (EMF) and Cybersecurity policies including Child Online Protection (COP) strategies.

Dubai's economy is diversified, relying predominantly on the trade, tourism, services and finance sectors. The use of productivity and economic development KPIs in Dubai can be important tools to support the achievement of city goals. During the assessment process, it was identified that Dubai has implemented several initiatives to enhance the use of ICTs to improve productivity and economic growth. The city is currently in the process of enhancing its assessments of the impact of ICTs in city economy, productivity and innovation capabilities. Dubai's experience in this area will also contribute to the KPI standardization processes on smart cities, economic growth and sustainable development, helmed by ITU.

The applicability of environmental sustainability KPIs in smart sustainable cities requires a deep understanding of the environmental challenges that cities face every day and how ICTs are able to address them in an efficient and optimal manner. Dubai has implemented several projects that highlight this important aspect, especially for the management of scarce resources such as water and energy. Dubai has included ICTs as key enablers to optimize the provision of urban services to Dubai citizens, thereby aiming for a more efficient water-to energy mix in the coming years. Under the leadership of the Dubai Supreme Council of Energy (DSCE), the city has been working to ensure energy sustainability and environment protection in collaboration with public and private sector organizations. The Dubai Municipality (DM) is also using ICTs to support the management of other environmental aspects such as air quality and waste management. The use of ICTs to reduce urban greenhouse gas emissions (GHG) in Dubai, is currently addressed by DSCE through new integrated policies and the analysis of the impacts of ICT-based projects in the utilities, transport, waste management and building sectors, which are major sources of GHG emissions in Dubai.

The city dimensions on equity and social inclusion have been evaluated with due consideration being given to their relationship to the Governance dimension of the city. Following the assessment carried out in Dubai by ITU, it is important to highlight that smart government services have been broadly deployed in the city. This reflects the adoption of a clear strategy and vision of Dubai in this matter. These actions form the key elements of Dubai's strategy, contributing towards the attainment of a future smart city model.

Quality of life KPIs that assess the impact of ICTs in the Health, Education and Safety sectors, were identified to be of relevance during the pilot project, as Dubai is a city that has implemented several ICT services in the health and city safety sectors. Based on their extensive knowledge and experience in the introduction of ICTs to improve the provision of these services, Dubai is invited to contribute to ITU standardization process for smart sustainable cities KPIs.

Physical infrastructure developments in strategic sectors such as energy and transportation are key to Dubai`s strategy to have an excellent smart city infrastructure. The city has developed several projects that introduce ICTs to improve the efficiency of service provision. The KPIs assessed within the scope of the smart city infrastructures in Dubai, show an important level of maturity linked the use of these technologies on a city level. This experience, can be taken to present and future smart sustainable city standardization efforts.

Following on from Section 3, the main results, key findings and learning opportunities for aspiring smart sustainable cities based on the first year of the pilot project in Dubai are elaborated in Section 4.

This Section provides best practices to improve the applicability of the KPIs to emerging smart cities based on the findings from the first year of the pilot project in Dubai. These best practices will allow for the effective implementation of the KPIs with the respect to the major strategic goals on smartness and sustainability set by each individual city. This section also analyses the preliminary observations of the KPI collection process and identifies several actions aimed at guiding cities to collect the data for verification and eventually become an internationally recognized smart sustainable city.

Key Terms

BAU	Business as Usual
COP	Child online protection
DCA	Dubai Culture and Arts Authority
DCD	Dubai Civil Defence
DDE	Dubai Data Establishment
DED	Department of Economic Development
DEWA	Dubai Electricity and Water Authority
DHA	Dubai Health Authority
DM	Dubai Municipality
DP	Dubai Police
DSC	Dubai Statistic Center
DSCE	Dubai Supreme Council of Energy
EMF	Electromagnetic Fields
FG SSC	Focus Group on Smart Sustainable Cities
GHG	Greenhouse emissions
ICT	Information and Communication Technology
ICTs	Information and communication technologies
IoT	Internet of Things
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
KHDA	Knowledge and Human Development Authority
KPIs	Key performance indicators
MBRSLP	Mohammed Bin Rashid Smart Learning Program
MED	Ministry of Economy –Department of Economy Development
ODC	Open Data Committee
RTA	Roads and Transport Authority
SDG	Smart Dubai Government
SD	Smart Dubai
SSC	Smart Sustainable Cities
SWM	Smart Water Management
TEC	The Executive Council of Dubai
TRA	Telecommunication Regulatory Authority
TTI	Travel Time Index
U4SSC	United for Smart Sustainable Cities
UAE	United Arab Emirates
UN	United Nations
UNECE	United Nations Economic Commission for Europe

1. Scope of work

In May 2015, Dubai, with the assistance of the International Telecommunication Union (ITU), became the world's first city to assess the efficiency and sustainability of its urban services using Key Performance Indicators (KPIs) developed by the ITU in ITU-T Recommendation Y.4901/L.1601 and Y.4902/L.1602.

Following the completion of the first year of Dubai's smart city pilot project with ITU, this case study documents and identifies the key findings for the initial year of collaboration between Dubai and ITU. This case study has taken into consideration the results obtained during the assessment and verification processes during the first year, as well as the in-depth research on the Dubai smart-sustainable city activities carried out by different entities.

Accordingly, this case study includes:

1) A brief description of ITU's work on smart sustainable cities.

2) A description of the vision, governance, and strategy adopted by Dubai to become a smart and sustainable city.

3) A concise outline of the methodology used in Dubai for the first year of the pilot project.

4) Overview of the smart city related activities carried out in Dubai under each ITU KPI dimension.

5) Identification of the best practices related to the use and applicability of the ITU Smart Sustainable Cities KPIs (ITU-T Recommendations Y.4901/L.1601 and Y.4902/L.1602) for smart and sustainable initiatives based on the first year of the pilot project in Dubai.

6) A list of key policy recommendations which can be implemented to bring about methodological improvements in the data collection process in cities starting their smart city expeditions.

7) Suggestions for improving the overall smart city experience for interested cities and ITU.

2. History

2.1. Origin of the ITU-T Recommendations on Smart Sustainable Cities

The International Telecommunication Union (ITU) is committed to accelerating the development of smart sustainable cities (SSC). In line with this, the ITU has been working on the development of a framework of policies and standards to promote the use of information and communication technologies (ICTs) for creating smart sustainable cities (SSC).

Together with United Nations Economic Commission for Europe (UNECE), ITU has formulated an international definition for smart sustainable cities (See Figure 1):

Figure 1 – ITU and UNECE's definition for smart, sustainable cities

"A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects".

Through its telecommunication standardization sector (ITU-T) Study Groups, ITU has developed a set of key performance indicators (KPIs) to facilitate the integration of ICT services in smart sustainable cities. These indicators are contained 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 in Recommendation ITU-T Y.4902/L.1602: *Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities*. Both Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 were approved as international standards (ITU-T Recommendations) on 5 June 2016.

These Recommendations (ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602) are being utilized to assist Dubai and other cities to evaluate ICT´s contributions in making cities smarter and more sustainable.

In May 2015, Dubai offered to pilot these KPIs to evaluate their city's performance and also agreed to assist the ITU in laying the foundation for a Global Smart Sustainable City Index, which can be used by emerging cities in the future to ascertain their "smartness" and "sustainability".

The Dubai pilot project aims to test and verify the KPIs contained in ITU-T Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 for the years 2014 to 2016. This pilot project will demonstrate the replicability and scalability of similar projects to other cities and will enable them to annually evaluate their smart city progress based on city performance indicators and metrics.

The results of this project will also facilitate the improvement and implementation of these KPIs on a global scale and contribute to the ITU standardization process for the establishment of a Global Smart Sustainable Cities Index. These ITU-T Recommendations not only provide the cities with a self-assessment tool but also support benchmarking studies, intercity comparisons and city learning.

Following the announcement of the implementation of the Dubai and ITU's smart city pilot project, various other cities including Valencia, Singapore, Buenos Aires, Manizales, Wuxi, Montevideo and many more have signed up for similar pilot projects.

ITU intends to use the results of these pilot projects to refine, update and modify, where required, the existing KPIs. ITU's pilot projects in Dubai (and other cities) has also helped set credible baselines and thresholds for each KPI allowing urban stakeholders to determine accurately whether their city is "smart" and "sustainable". The baselines for the KPIs will also be appropriately included in the Global Smart Sustainable Cities index.

In effect, the Dubai smart city project forms an integral part of the on-going standardisation efforts for smart sustainable cities within ITU.

The international standards implemented in Dubai, together with the Recommendation ITU-T Y.4903/L.1603 "*Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals*", are expected to set the basis for a KPI assessment framework for smart sustainable cities on a global level.

The experience derived from Dubai's implementation of these KPIs will be a key input to the development of a global set of KPIs for smart sustainable cities to achieve the sustainable development goals (SDGs). These KPIs are being developed together with 16 UN agencies and programmes within the United for Smart Sustainable Cities (U4SSC) Initiative which was established in response to Sustainable Development Goal 11: "*Make cities and human settlements inclusive, safe, resilient and sustainable"*.

Dubai Smart city pilot project will also set the basis for a "Global Smart Sustainable Cities Index" which is expected to be finalized by July 2017. The work on the Global Smart Sustainable Cities Index will be supported by the "*United for Smart Sustainable Cities*" (U4SSC) initiative.

The existing ITU KPIs for smart sustainable cities are categorised according to various dimensions as listed and defined in Table 1. These dimensions organize the KPIs into the common themes that smart and sustainable cities should review as part of their goal setting and implementation activities.

Table 1 – Six dimensions of Smart Sustainable Cities (as categorised in the ITU-T Recommendations)

Dimension	Description
1) Information & Communication Technologies	▪ The KPIs within this dimension aim to assess the availability and use of ICT infrastructure in cities to facilitate smart sustainable city services. ▪ Cities should demonstrate that they have secure and reliable ICT infrastructure, services, and customer-friendly services and devices. ▪ ICT networks and information platforms should contain effective mitigation of possible risks associated with the use of ICTs (e.g. electromagnetic fields, privacy issues and child online protection).
2) Environmental sustainability	▪ The KPIs within this dimension aim to assess the use of ICTs in supporting urban environmental services and improving the overall environmental quality in cities.
3) Productivity	▪ The KPIs within this dimension aim to assess the use and impact of ICTs in the economic development of cities. These KPIs cover innovation, job creation, trade and productivity. ▪ These KPIs are also expected to play a pivotal role in assessing a city's adoption of ICT to support socio-economic growth.

**Table 1 – Six dimensions of Smart Sustainable Cities (as categorised in the
ITU-T Recommendations)** *(end)*

Dimension	Description
4) Equity and social inclusion	▪ The KPIs within this dimension aim to assess the impact of the use of ICTs to promote urban equity, citizen participation and to enhance social inclusiveness. ▪ These KPIs focus on qualities such as equity, governance, city openness and public participation
5) Quality of life	▪ The KPIs within this dimension aim to assess the impact of ICTs to improve citizens' quality of life. ▪ These KPIs focus on areas such as education, health and city safety.
6) Physical infrastructure	▪ The KPIs within this dimension aim to assess the impact of ICTs on city infrastructure, development, and sustainability. ▪ Aspects evaluated by these KPIs include infrastructure for the provision of city services such as water and waste management, energy, sewage, transport, road infrastructure, and buildings.

3. The essence of the pilot project in Dubai

3.1. Overview of Dubai

Dubai is one of the seven emirates that make up the United Arab Emirates (UAE), which was established as a nation in 1971. It is located on the Eastern coast of the Arabian Peninsula in the southeast corner of the Arabian Gulf. Dubai has an area of 4,114 km², and is the second largest emirate in the UAE.

Situated on the banks of the Dubai Creek, the Emirate initially emerged as a small trading hub. Today, Dubai ranks as the UAE's most important port and commercial centre. Dubai is also one of the 10 cities to have the highest growth rates between 1990-2014. Dubai has become an attractive holiday destination with 10 Million tourists a year (as of 2012) (Smart Dubai, 2016). As of 2015, the population of the Emirate of Dubai was estimated to be 2,446,675 (Dubai Statistics Center, 2016). Table 2 depicts the profile of Dubai.

Table 2 – Emirate of Dubai profile – Year 2014 (Dubai Statistics Centre, 2016)

Item	Unit	Value	Observation
City Area	km²	4.114	Includes the desert area
City Inhabitants	Inhabitants	2.327.350	Includes only residents. Value for the 1st Quarter of 2014
City Households	Units of households	452.935	
City Density	Inhabitants/km²	565	
Active population	Inhabitants	1.081.000	People working in the city from 6:30 am- 8:30pm in city

As Dubai is an integral member of the UAE, it is also bound by the UAE Vision 2021, which was launched in 2010. Under the UAE Vision 2021, several national priorities have been identified. These priorities are expected to be adopted by each of the Emirates including Dubai. The

national priorities represent the key focus areas of government action for the coming years (See Figure 2).

Figure 2 – United Arab Emirates National Priorities under the UAE Vision 2021

1. United in Responsibility: promoting a cohesive society and preserving identity
2. United in Destiny: offering a safe public and fair judiciary
3. United in Knowledge: creating a competitive knowledge economy
4. United in Prosperity: build a first-rate education system, a world-class healthcare system, a sustainable environment, and infrastructure

The priorities given in Figure 2 are built on a set of national indicators related to education, healthcare, economy, police and security, housing, infrastructure and government services. These long-term indicators measure performance outcomes of each of the national priorities and are periodically monitored by Government leadership across the UAE, with a goal of achieving set targets by 2021 (UAE, 2016).

Owing to the foresight of Dubai's ruler, His Highness Sheikh Mohammad Bin Rashid Al Maktoum, and in view of the UAE Vision 2021, Dubai has adopted a new approach to urban planning that combines modern city elements with traditional culture. The Ruler of Dubai equates technology to a building block which can provide an extraordinary quality of life. In this regard, technology is not considered Dubai's end goal. (Smart Dubai, 2016) This new approach has made Dubai a centre of international trade and tourism.

While aligning its city vision with the UAE Vision 2021, the Emirate of Dubai has established a group of objectives that focus on happiness and quality of life, as defined by the overarching Dubai Plan 2021. The vision of the Dubai smart city initiative also aims "to make Dubai the smartest and happiest city on Earth". (Smart Dubai, 2016)

The Dubai Plan 2021 also addresses the urban environment and examines the interaction of Dubai's residents with their environment and the economic and social services provided (Government of Dubai, 2016). Overall, Dubai's urban strategy also includes public commitment through a communications strategy to create a "city of happy, creative & empowered people", within an "inclusive and cohesive society" in a "smart and sustainable city" (Dubai Plan 2021).

The objectives set forth within the Dubai Plan 2021, are divided into 6 themes, each highlighting a group of the strategic developmental aims for Dubai as described in Figure 3.

Figure 3 – Dubai Strategic Goals (Government of Dubai, 2016)

- The **People**: "City of happy, creative & empowered people"
- **The Society**: "An inclusive & cohesive society"
- **The Experience**: "The preferred place to live, work & visit"
- **The Place**: "A smart & sustainable city"
- **The Economy**: "A pivotal hub in the global economy"
- **The Government**: "A pioneering and excellent government"

As part of Dubai's vision to become a smart sustainable city, their governance model brings together multiple stakeholders to drive growth and promote the use of smart services. Active participation by citizens and establishing private–public partnerships are also elements of the City's governance strategy.

3.2. Dubai's governance mechanisms and smart sustainable city strategy

A cornerstone for Dubai's decision-makers is to prioritise the needs of the inhabitants while implementing technologies that create a smart sustainable city. This central goal to improve the quality of life of the city's inhabitants through novel, more efficient, and increasingly inclusive ICT-enabled approaches (Smart Dubai, 2016) is well documented in Dubai's official smart city report. The various smart city activities conducted within Dubai fall under its official smart sustainable city initiative which is referred to as "Smart Dubai".

The Executive Office of Dubai launched the Smart Dubai initiative and remained the entity responsible for managing smart city projects in the Emirate until the legal formation of the Smart Dubai Office. In November 2015, the Smart Dubai Office with an expanded leadership team officially took over the duties related to the Smart Dubai initiative.

The Smart Dubai initiative is aligned with UAE Vision 2021 and is a major initiative contributing to the success of Dubai Plan 2021. One distinct feature of Dubai's aim to become the world's smartest city by 2017, is that it has pegged "happiness" as a decisive measure of success of its smart city goal. Accordingly, the Smart Dubai initiative aims to combine effectiveness, positive outcomes, and technological and architectural advancements to benefit citizens and to promote environmental sustainability and economic growth The objectives and pillars set forth by the Smart Dubai initiative cater to both the UAE's National Vision 2021 and the Dubai Plan 2021 (which aim for sustainable development along with bestowing its citizens with prosperity, security, stability and a life filled with dignity and respect).

Smart Dubai is based on a unified strategy combined with a leadership model that builds upon existing and successful initiatives. In line with its Smart Dubai initiative, Dubai aims to be a city where: (i) resources are optimised for maximum efficiency, (ii) services are integrated seamlessly into daily life, (iii) people and information are protected, and (iv) the most enriching life and business experience possible is created for all (Smart Dubai, 2016).

Within the Smart Dubai initiative, four strategic pillars have been defined as the core areas of a unified effort from the City's leadership towards its vision. These provide a different view of the impact the city needs to create in tandem with all public and private stakeholders (See Figure 4).

Figure 4 – Smart Dubai Pillars (Smart Dubai, 2016)

To further propel their smart city dream, Dubai has established effective institutional governance arrangements with dedicated organizational support to secure the participation of citizens as well as other smart city stakeholders. A tiered partnership framework supports Smart Dubai, which enables government, private sector actors and institutions to engage and collaborate on achieving the vision of Dubai authorities and leaders. Building on a foundation of eleven strategic founding partners, Smart Dubai brings together multiple stakeholders to drive growth and foster the use of smart services. In addition to these partners, other entities also render their support to Smart Dubai for transforming the city into a smart sustainable city (See Figure 5).

Figure 5 – Eleven Strategic Founding Partners to achieve Dubai vision

In order to attain the Smart Dubai vision, Dubai's partners develop projects in their areas of expertise and define outcomes aligned with Smart Dubai objectives. Smart Dubai has defined a group of four tools and initiatives to assess the performance and impact of the different services implemented across the Emirate (Smart Dubai, 2016). These tools and initiatives include:

1. **The Happiness Meter** is one of Dubai's first strategic "smart city" initiatives. It aims to collect citizens' experience and feedback, through a centralised data dashboard.

2. **Smart District Guidelines** is a reference guide that empower district developers and promotes a truly seamless and impactful city experiences for all residents and visitors in line with the strategic vision and plans of Smart Dubai.

3. **The Dubai Data initiative**, led by the Dubai Data Establishment and decreed by the Dubai Data Law of 2015, is the most comprehensive citywide data initiative guiding the opening and sharing of city data across the public and private sector.

4. **Smart Dubai Index** is an impact assessment tool to be developed by Dubai to measure how facilities and services in Dubai contribute to the vision of Smart Dubai, based on ITU's KPIs for SSC. It also incorporates additional KPIs pertinent to Dubai's smart city strategy.

Under Smart Dubai, there are over 150 "mini-initiatives" and a plan to transform city services into smart services. These initiatives underpinning Dubai's smart city objectives are expected to nurture an open and transparent governance system which can serve its citizens with a seamless network of urban services designed to improve their overall quality of life (Smart Dubai, 2016). To achieve this, Smart Dubai aims to encourage collaboration between the public and private sectors and achieve the designated targets in six "smart" focus areas or strategic dimensions: smart people, smart environment, smart living, smart economy, smart governance, smart mobility and smart ICT infrastructure (See Figure 6). Furthermore, the success of the Smart Dubai strategy is premised on three basic principles: communication, integration, and cooperation, which aim to move away from departmental silos and promote concerted efforts.

Figure 6 – Dubai Smart City Dimensions (Smart Dubai, 2016)
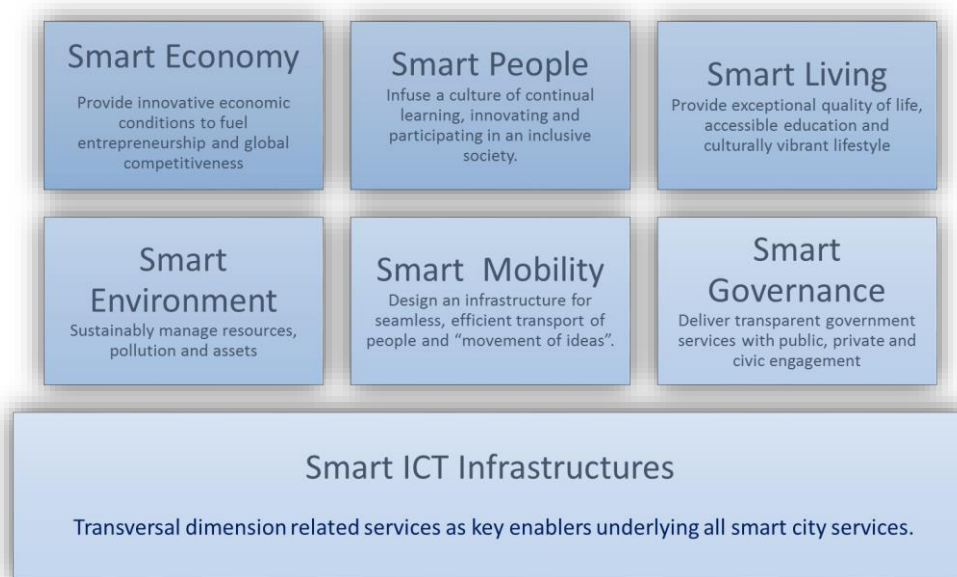
Dubai's six strategic dimensions reinforce the delivery of the smart city across specific vertical sectors in the city. Additionally, this structure has facilitated the assessment of the KPIs' applicability to Dubai, as they are coherent with smart sustainable city dimensions and sub-dimensions identified within the KPIs developed by the ITU.

The existing governance and administrative structures, aided by Dubai's ability to harness the potential of ICTs have enabled researchers to understand the workings of a city at a level of unprecedented detail. This understanding has allowed for the provision of new and innovative services to citizens and local businesses along with the ability to transform the behaviour patterns of civil servants, local business, and residents to achieve Dubai's stated social, environmental, and financial outcomes. Given the progress achieved in this turf, the different smart sustainable city activities across Dubai's smart city strategy dimensions are mature enough to be assessed through the proposed ITU KPIs.

During the KPI assessment process, smart city activities were identified and the data collected reflects a comprehensive integration of information communication technologies in the delivery of Dubai city services. The implementation of these KPIs has made ***Dubai the first city in the world to have analysed the smartness and sustainability of its urban services taking the Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 as reference.***

3.3. Methodology used in the Dubai case study

Dubai has an established assessment framework to measure the impact of the use of information and communication technologies within the Emirate. Within this framework, Dubai has initially utilized the Smart Sustainable Cities KPIs contained in ITU-T's Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 to evaluate the implementation of their smart city initiatives.

The smart sustainable cities KPIs pilot project implemented by ITU in Dubai included the KPI collection process and its subsequent assessment and verification. These steps are incorporated in the ITU Smart Sustainable City KPI Collection process (as described in Figure 7).

Figure 7 – ITU SSC KPI Collection Process contained in ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602

1. ITU KPIs collection request	2. Internal KPI analysis & identification of sources	3. Data collection for KPIs	4. ITU SSC KPIs reporting	5. ITU KPI Assessment	6. Data verification	7. ITU evaluation

The lessons learned and the insights gained during the SSC KPI collection process in Dubai, have been instrumental in the drafting of a methodological guide, which provides instructions on how the process could be replicated for the KPI data collection in other cities around the world.

3.3.1. Dubai's data collection and reporting process for Key Performance Indicators

The process of KPI collection in Dubai was facilitated by Smart Dubai and consisted of the following activities:

(i)   Coordination and gathering of data by different entities

Smart Dubai coordinated the data collection process, organized the analysis of the scope and applicability of KPIs with each of the collaborating entities, and delivered the formal request for collecting the data to them. Prior to this process, an analysis of the synergies between Smart Sustainable Cities KPI Dimensions contained in ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 and Smart Dubai dimensions was carried out between ITU and Smart Dubai. The results of this comparative analysis are described in Table 3.

Table 3 – ITU SSC KPIs dimensions analysis for Dubai

ITU Dimension (s)	Dubai Dimension (s)
1) Information & Communication Technologies	1) Smart ICT Infrastructure
2) Environmental sustainability	2) Smart Environment
3) Productivity	3) Smart Economy
4) Equity and social inclusion	4) Smart Governance
5) Quality of life	5) Smart Living
-	6) Smart People
6) Physical infrastructure	7) Smart Infrastructure and Mobility

Smart Dubai informed the various entities and departments that they would be involved or impacted by data collection process. In addition, interactive discussions were held during the months of August and September 2015 to facilitate an understanding of the KPIs and the collection process. As a result, the study identified the need to define the scope of the assessment boundaries, and to give consideration to basic characteristics of the city, such as inhabitants, geographical boundaries, etc.

Several reporting issues that could ultimately impact the KPI reporting were also identified. For example, the daily population working but not living in the city was flagged as potentially shaping data interpretation. Furthermore, the importance of clarifying the boundary of the KPIs reported on a national or city level to avoid deviations in the data was also realized.

(ii)   Assessment, evaluation and verification of the KPI data collected

Smart Dubai and ITU collaborated on completing the assessment process. In November 2015, ITU and Smart Dubai Office conducted a detailed analysis of the KPIs and data collection process. The applicability of these KPIs to the city was determined through interactive interviews and visits to various Dubai entities, which own the data and manage the different aspects evaluated. The entities that contributed to the data and KPI collection process are described in Table 4.

Table 4 – Collaborating entities in the KPI collection, assessment and verification process

Abr	Entity	Brief description of entity role
SD	Smart Dubai Office	This is the Entity leading the transformation of Dubai into a Smart City. They are the focal point for the ITU SSC Indicators project.
DCA	Dubai Culture & Arts Authority	This is the Entity in charge of managing the city services related to culture and arts.
DEWA	Dubai Electricity and Water Authority	This Dubai Utilities provider is in charge of water and electricity provision to the Emirate of Dubai. They manage all electricity services including generation, transmission and distribution. They are also responsible for water desalinization plants and piped water systems.
DHA	Dubai Health Authority	This Dubai Entity is in charge of the provision of the public health services in Dubai. They are also in charge of developing regulations to follow up on Private Sector activities which are aligned with Federal Government Activities.
DM	Dubai Municipality	This Dubai Entity is in charge of city administration in terms of urban planning, building sector, land use, environmental quality management, food and products safety and provision of general city municipal services.
DP	Dubai Police	Dubai Police Force is an integral part of the UAE Police Force with the mission to improve the quality of life in the country, by operating in accordance with the constitutional rights to enforce the law and maintain security and safety of the community and of everyone living in the country.
DSC	Dubai Statistics Center	This is the official entity in Dubai which is in charge of carrying out surveys, collecting data, analyzing data and reporting Dubai's national statistics.
SDG	Smart Dubai Government	This Entity is a core establishment under the Smart Dubai Office and in charge of the transformation of city services into e-services. They provide shared services to all public entities in Dubai to facilitate the provision their city e-services, in addition to providing policies and guidelines to govern and guide entities in their transformation.
KHDA	Knowledge and Human Development Authority	This Entity is in charge of the private education services in Dubai. They do not cover public sector initiatives which are the responsibility of the UAE Ministry of Education.

Table 4 – Collaborating entities in the KPI collection, assessment and verification process
(end)

Abr	Entity	Brief description of entity role
RTA	Roads and Transport Authority	RTA is responsible for planning and providing the requirements of transport, roads & traffic in the Emirate of Dubai, and between Dubai, other Emirates of the UAE, and neighbouring countries in order to provide an effective & an integrated transport system capable of achieving Dubai's vision & serving the vital interests of the Emirate. RTA develops integrated and sustainable transportation systems through the preparation of policies and legislations which focus on adopting technologies and innovative approaches, and implementing best-practices and standards.
TRA	Telecommunications Regulatory Authority	This is the UAE Telecom Regulatory Entity. They manage and control all ICT related processes on a national level and on an Emirate level.
DCD	Dubai Civil Defence	This Entity is in charge of managing firefighting processes in Dubai together with the provision other public safety processes
DED	Department of Economic Development	This Entity sets and drive the economic agenda of the Emirate of Dubai including the development of economic plans and policies, identification and support the growth of strategic sectors, and provision and services to domestic and international investors and businesses.
DDE	Dubai Data Establishment	The Dubai Data Establishment (DDE) is one of the core agencies within the Smart Dubai Office, and is responsible for supervising the implementation of the 2015 Dubai Data Law, which was drafted by its predecessor, the Dubai Open Data Committee (ODC). The Law assigns 19 specific duties and powers to the DDE, including preparation and oversight of Dubai's data strategy, regulatory framework, and implementation roadmap; and development and enforcement of policies, standards, and guidelines for open data publication and inter-organizational data sharing in Dubai.
DSCE	Dubai Supreme Council of Energy	It is the governing body tasked with policy development, planning and coordinating with concerned authorities and energy bodies to deliver new energy sources while employing a balanced approach to protecting the environment. It is in charge of the carbon accounting process in the city.
TEC	The Executive Council of Dubai	This is the Dubai Government Entity in charge of managing the implementation of Dubai Vision 2021.
MED	Ministry of Economy	This Ministry is in charge of Dubai's economic policies development and reporting of related economic KPIs to DSC.

During the assessment process, each entity assisted with KPI analysis. This provided an understanding of the scope of each KPI in the city and its contribution to achieving the City's vision. Part of this analysis also included assessing the relevance of the KPIs as a measurement tool for Dubai, which could help to improve the smart city initiatives and the overall project performance.

The data collected by Dubai was reviewed during an onsite visit in December 2015 by an independent auditor[1] accredited to a number of global management systems and indicator standards. The objective of the verification process was to validate the data reported by Dubai entities and analysed during the assessment phase. This independent review aimed to examine the data submitted by Dubai, provide feedback on suitability of the KPIs and provide inputs into the process for future revisions, based on the Dubai's ability to collect data that is verifiable.

The process included:

(a)   in-person interviews with senior management at the various Dubai entities,
(b)   review of KPI data submitted, and
(c)   review of the underlying data sources.

The verification process revealed the following findings:

(i)   19% of KPIs require further analysis and evaluation prior to their reporting,
(ii)   10% were not applicable for Dubai in the 2014 collection period,
(iii)   14% were not reported by the city
(iv)   57% were reported.

The independent verifier was able to completely verify 62% of the 57% of KPIs that were reported.

The complete verification and data collection were determined to be possible only when the definitions of the KPIs are improved and the data required to be collected is also better defined. This suggests that future pilot projects conducted on similar lines should be conducted preferably after there is more clarity provided on the KPIs and the required data to be collected. As the Dubai pilot project moves towards the second year of its implementation, it is important to understand that the results and findings from the first phase will be considerably updated and enhanced. Therefore, these results from the first year ideally should not be used for comparison purposes with other cities. In effect, the findings of the first year of Dubai's pilot project can be considered the stepping stone for consolidating a methodology, KPI framework and suggestions which will serve the smart city community for decades to come.

Following the completion of the first year of the pilot project, Dubai's efforts in collecting and reporting the data based on the preliminary versions of the KPIs are to be commended for not only making a significant contribution to the KPI improvement process, but also in demonstrating global leadership in this field.

3.4. Overview of Dubai's smart sustainable city activities: A sneak peek at Dubai's evolution

Dubai's pathway to becoming a smart sustainable city has been shaped by a clear vision and an efficient governance model. This is complemented by Dubai's six strategic dimensions, which reinforce the delivery of the smart city strategy across specific vertical sectors in the city.

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[1]   Mr. John Smiciklas served as the Auditor for the verification process in Dubai.

In this context, Dubai has introduced and operated different smart sustainable city activities across their strategic dimensions that are mature enough to be assessed through the proposed ITU KPIs. The smart city activities carried out in Dubai have been developed by the different entities over the last few years. Subsequently, the move to assess the performance/progress of these activities has been triggered by creation of the Smart Dubai initiative (Smart Dubai, 2016).

During the KPI assessment and verification process, the smart city activities described in this Section have been identified and the data collected reflects a comprehensive integration of ICTs in the delivery of Dubai city services.

The desired triumph linked to the implementation of Dubai's smart sustainable city initiative is based on two criteria: (i) smart city practices implemented by the different entities that contribute to Smart Dubai's vision; and (ii) Dubai's ability to measure performance using different smart sustainable city KPIs contained in ITU-T Recommendations during the first year of evaluation.

This section highlights a few of the Dubai's smart city activities within each dimension of the ITU SSC KPIs. The analysis of each KPI (for Dubai) has been elaborated on in Annex 1.

3.4.1.   Dimension 1: Information and communication technologies (ICT)

The ITU KPIs which assess ICTs have been considered by Dubai within their transversal strategic dimension of ICTs. These KPIs have also been determined to be a key enabler in reaching the Smart Dubai goals.

Dubai has demonstrated that to become a smart-sustainable city, cities should they have a secure and reliable ICT infrastructure, and a portfolio of important services and devices that citizens can use. In view of this, ICTs are an integral part of Dubai's urban administration framework. The development of ICT infrastructure to deliver services in the city is promoted and regulated by the Telecommunication Regulatory Authority of the UAE (TRA); which is responsible for the regulatory aspects of the telecommunications and information communications technology industries in the UAE (TRA, 2016).

Smart Dubai works closely with TRA to define and understand the most efficient measurement framework for ICT use to achieve its smart city vision. To achieve this, KPIs are collected at a national level and then are reviewed and interpreted to the Emirate level with an understanding of the national and local context (while also taking into account international standards). This allows traceability of the data and also helps facilitate an understanding of ICT policies for the development of smart sustainable city projects. This cooperative work between Smart Dubai and TRA provides a positive example for other cities (See Box 1).

Box 1 – ICTs KPIs extrapolation to a local and emirate level

TRA assesses the performance of ICTs and network development on a national level. For example, one of the surveys they design, the ICT Household Survey, occurs every two years. TRA also carries out the annual market review, which summarizes the state of the fixed, mobile, and data telecommunications services in the UAE in terms of subscribers, penetration, revenues, usage (traffic volumes) and quality of service.

UAE's high quality ICT data and understanding of the importance of KPIs for decision-making facilitates the extrapolation of the data to a local level thereby supporting Dubai in their process of assessing the impact of ICT use. This is not applicable to all cities of the world, as sometimes ICT data is only reported on a national level and city level data is always not available. Dubai and TRA counts on the support of the Dubai Statistics Center (DSC) to carry out surveys and processes the ICT data to build performance metrics for decision-making.

Another important aspect related to the sustainability of smart cities and the roll out of ICT Technology, is Electromagnetic Fields (EMF). It is an emerging issue that has attracted attention and discussion in the context of smart sustainable cities due to increasing awareness on this matter. ITU SSC KPIs provide a one of a kind assessment framework to support smart cities in the process of assessing the impacts of EMF on a city level and to facilitate the process of incorporating EMF policies into smart city initiatives. UAE is committed to following international guidelines on EMF. TRA issued an EMF guideline endorsing international non-ionizing radiation guidelines in 2010 (TRA, 2010). Dubai Municipality Environment department has endorsed these guidelines in Dubai through the "Guidelines for the Sitting and Installation of Telecommunication Towers" in 2013 (Dubai Municipality, 2013).

With reference to security and privacy aspects, Smart Dubai, through its Dubai Data Establishment (DDE), defines policies in data confidentiality and privacy. In 2016, the Dubai Data Establishment began addressing these issues collectively with several key public and private institutions, such as the Dubai Electronic Security Centre (DESC), TRA, and the Dubai Police Department. Smart Dubai and Dubai Data Establishment are addressing information security with Dubai Electronic Security Center through the "Dubai Information Security Regulation."

3.4.2. Dimension 2: Environmental sustainability

ICT offers technologies that help cities manage environmental resources such as water and energy. Cities also rely on smart technologies to facilitate environmental quality management and control processes, such as, air quality management, noise control or green area maintenance.

Dubai faces environmental challenges similar to leading metropolitan cities in the world including air pollution, waste management, and high CO_2 emissions. Dubai manages these environmental challenges through different entities such as Dubai Municipality (DM), the Dubai Electricity and Water Authority (DEWA), and the Dubai Supreme Council of Energy. All of these entities shape the environmental sustainability of the city and collaborate with Smart Dubai to identify opportunities for the introduction of ICT related services. Such services improve the efficiency of management processes, environmental resources, and related infrastructures.

Dubai is currently improving the collection of environmental information linked to the use of ICTs in order to enhance city environmental services within its different entities. In this regard, Dubai has been able to collect several KPIs related to the evaluation of environmental management, especially the ones related to environmental quality. Dubai entities are in the process of understanding the importance of ICT use to achieve a greater level of efficiency in environmental quality monitoring and control.

A review of the various entities in Dubai is presented in the ensuing paragraphs.

Dubai Municipality is in charge of waste management, city environmental quality control (including air quality, wastes, wastewater and sewage management), and green areas development. Dubai Municipality is utilizing clean and ICT-based technologies to improve efficiencies in their systems and facilitate decision-making.

Dubai's Electricity and Water Authority manages energy and water supply in Dubai. It owns, operates and maintains Dubai's power stations and desalination plants, aquifers, power and water transmission lines, and power and water distribution networks.

ICTs are becoming an integral part of the delivery of energy and water services especially due to the inclusion of smart metering solutions for the whole Emirate. Dubai has defined a clear roadmap to reach a smart grid model in the following years, on which energy and water consumption patterns will shape the future sustainability of these services. See Box 2 for more about Dubai's energy and water provision service.

Box 2 – Smart and integrated management of energy and water in Dubai (DEWA, 2015)

Energy and water provision service is integrally managed by Dubai Electricity and Water Authority, which is a key partner of Smart Dubai and drives smart transformation. The Emirate is working towards a smart-grid strategy for efficient management of energy in the City, including demand-side management and operational improvement activities. Smart-grid implementation is a key criterion for Dubai to successfully become a smart city. The program to achieve this includes: advanced metering infrastructure, asset management, demand response, distribution automation, information technology infrastructure, substation automation, system integration, telecommunications, and big data analytics. The seamless availability of round-the-clock integrated and connected services that meet daily living requirements is essential.

In 2009, Dubai Electricity and Water Authority began its transformation into a smart-grid utility. In 2010 the Authority launched a smart application for smart phone and tablet users that provides over 150 services and features that make life easier for everyone, including people with special needs, by enabling users to complete transactions anytime, anywhere.

Dubai Electricity and Water Authority also offers smart applications and smart meters, which includes the installation and retrofitting of smart meters across Dubai in order to enable owners and residents to monitor and measure their energy and water-use. Dubai is installing 200,000 meters in the first phase and providing smart applications to allow remote access to meters. This will enhance smart grid development and enable the complete monitoring of energy and water-use in Dubai. Within five years, Dubai expects to have over 1,200,000 smart meters installed throughout the Emirate.

Dubai has also defined an Integrated Energy Strategy, which aims to increase clean energy sources in Dubai's total installed power capacity to 25% by 2030 and 75% by 2050. This strategy covers the building, transportation, and electricity sectors, which will be further explored in the Infrastructure Dimension.

On the climate change front, the Dubai Government works with the Supreme Council of Energy (DSCE) to define policies and measurement frameworks for energy, GHG emissions, and climate change indicators in the Emirate. The DSCE, through Dubai Carbon Centre of Excellence (Dubai Carbon), is responsible for CO_2 emissions accounting process for Dubai, based on the IPCC guidelines, as part of Dubai's Carbon Abatement Strategy 2021. A first in the region, the Dubai Carbon Abatement Strategy 2021 details sector-based reduction targets for greenhouse gases, aiming to decrease emissions by 16% compared to business as usual (BAU) in 2021 (Dubai Carbon, 2016).

3.4.3. Dimension 3: Productivity

Dubai has become a major business hub with a dynamic and diversified economy in the last three decades. The city has been noted to have a first-rate infrastructure, an international outlook, and liberal government policies that attract investors and fosters the development of new activities (Government of Dubai, 2015).

Smart Dubai works together with the Department of Economic Development in the structural transformation of Dubai into a diversified, innovative, and service-based economy that aims to improve the business environment and accelerate productivity growth. In doing so, the Department of Economic Development and its agencies develop economic plans and policies, identify and support the growth of strategic sectors, and provide services to domestic and international investors and businesses. For example, Dubai has launched a new e-service called "Saad" – Simply ask, an intelligent advisor service that applies cognitive computer solutions to facilitate business licensing and registration in Dubai to foster entrepreneurship in the city. The 'Saad' service will allow business community users, to ask questions and get up-to-date information on business licensing and registration processes in Dubai processes.

Smart Dubai, DED and the Dubai Statistics Centre work to assess the impact ICTs have on the economic growth in the city, through a standardized review of economic indicators. This centralized management control allows for transparent reporting and traceability of the economic performance of smart city initiatives in Dubai. This cooperation among different actors facilitates the incorporation of new KPIs and data collection processes to address the needs of Dubai in assessing the impact of the use of ICT`s in city economic growth.

Dubai's Smart Economy dimension provides innovative economic conditions to fuel entrepreneurship and global competitiveness in the city. Key performance indicators, which are able to measure ICT innovation, job creation, and trade growth enhance the potential of cities to become economic engines and to improve quality of life of their citizens.

Smart Dubai is developing new KPIs and performance methods that require new collection methods, alternative collection frequencies, and specialized analyses. See Box 3 for a description of how central data management is used to assess Dubai's growth and sustainability.

**Box 3 – Central data management to assess Dubai growth and sustainability
(Dubai Statistics Centre, 2016)**

Dubai has a centralized process to manage statistical data of the city with the support of Dubai Statistics Centre which undertakes statistical and specialized activities, carrying out the general census of population, and the count of houses and other establishments. It also conducts economic and social statistical surveys and publishes statistical data for the Emirate of Dubai as a whole. Dubai Statistics Centre has a modern and comprehensive statistical system ensuring that it is the only official source for the collection, analysis, and publication of all statistical information and data for Dubai.

The information published is managed and processed under international standards on the collection, analysis and dissemination of data. This information, systems and statistical databases meet the requirements of planning and comprehensive development processes which help support decision-making processes at all levels in Dubai. Dubai Statistics Centre advises and provides services to the different Dubai entities for the development surveys and statistical analysis of their particular activities and interests. Most of the information generated is available to all users under an open and/or shared data platform.
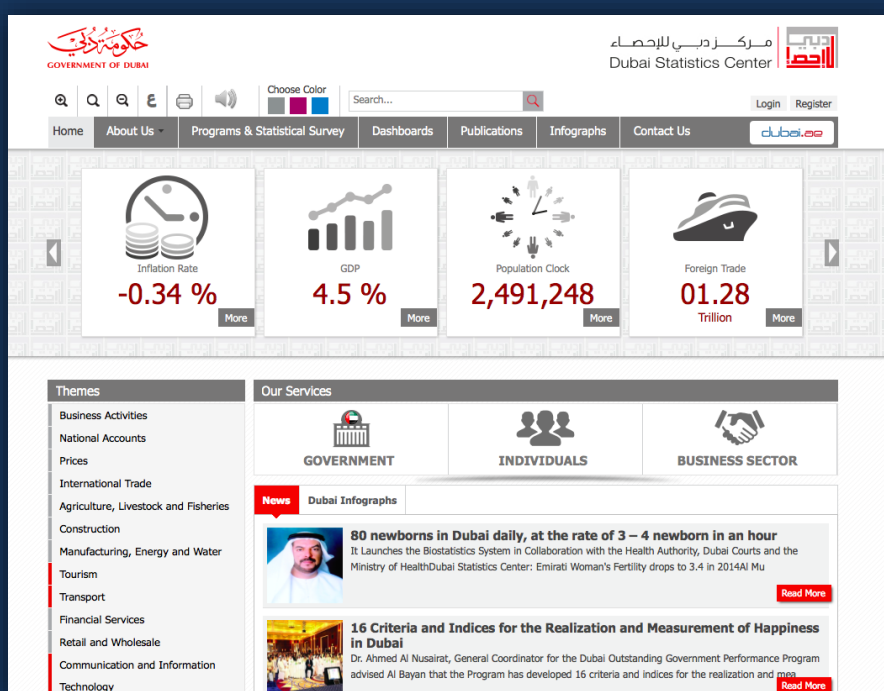
3.4.4. Dimension 4: Equity and social inclusion dimension

Information and communication technology can provide tools that facilitate active citizen participation. A smart sustainable city needs to be inclusive, and deliver new types of technologies to vulnerable or marginalized sectors of the population. Barriers to technology adoption can include technology scepticism or users who may feel intimidated by new technological tools. This constitutes an important social challenge that requires designing of strategies aimed at building trust, addressing public fears about technological change, and fostering adoption of new technologies.

An integral part of realizing Dubai's smart city goals lies in empowering people to participate actively in city initiatives, with the provision of e-government, and more recently smart government services (Smart Dubai, 2016).

The technology arm of Smart Dubai, Smart Dubai Government (SDG), officially directs and supervises the implementation of electronic and smart transformation in the Dubai Government. SDG is in charge of overseeing smart transformation processes at the level of government entities; reviewing government entities' plans and budgets related to smart transformation, IT, smart services and infrastructure; and proposing legislation necessary for easing the smart transformation process (SDG, 2016).

Following the assessment carried out in Dubai by ITU, it is important to highlight that smart government services have been broadly deployed in the city, suggesting a clear strategy and vision for the City. The KPIs related to these types of services reported by SDG show maturity in the delivery of e-public services for all citizens.

E-governance is the use of ICT by different actors aimed at improving access to information and building capacities. Dubai is an interesting example of this as part of the services provided to citizens allows active participation and engagement. Such services include DubaiNow [2] (as detailed in Box 4), e-Complaint System (described in Box 5 and Box 6) along with the Mohammad Bin Rashid Smart Majlis (outlined in Box 7).

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[2] Dubai to launch smart app for 2,000 government services. Retrieved from http://gulfnews.com/news/uae/government/dubai-to-launch-smart-app-for-2-000-government-services-1.1625556

Box 4 – DubaiNow Platform to promote active public participation
(Dubai Government, 2016)

The DubaiNow app, which was the first channel to be introduced on the DubaiNow platform, was launched at GITEX 2015. The comprehensive app, which is currently available for iOS and Android, provides an integrated city service experience supporting the daily needs of Dubai residents, with more than 55 services available from 24 government entities. DubaiNow won the Best m-Government Service Award in the One Stop App category at the national level during the World Government Summit 2016 and the 'Best Government Mobile App of the Year' category at the '.GOV Awards 2016' for Dubai and the northern emirates.

Smart Dubai maintains that the DubaiNow platform is a powerful example of what can be accomplished when the city works together. By providing a unified window to Dubai city services through DubaiNow, Smart Dubai and its partners are making city experiences more seamless and impactful. With shared data enabling services for identification and payments, the city becomes more efficient and more secure. The DubaiNow application includes an array of innovative and interdependent government services that support easy and smooth transactions, benefiting from shared data. These service packages are classified under 11 categories: payments and bills; public transport; security and justice; health; driving; visas; educational services; Islamic services; business; housing; and public services. Users can seamlessly transition from accessing paediatrician services to paying a phone bill or traffic fine (etc.), in a unified app experience.

All customers who have existing accounts with mPay or MyID service (provided through Smart Dubai Government) will be able to use their login to access DubaiNow easily and take maximum advantage of an array of service packages that have been created based on customers' interests.

A total of 4 million transactions were conducted through the DubaiNow app in 2015. As of November 2016, the DubaiNow app has been downloaded 288,100 times.

Box 5 – Description of Smart Dubai' eComplain system (Smart Dubai Government, 2016)

Using multiple channels, Smart Dubai Government (SDG) promotes Dubai Government's use of information and communication technology to provide government services to citizens, visitors, businesses, government entities, and government employees. SDG does this in line with their mandate to ease the lives of people and businesses interacting with the Government.

In its role as facilitator of smart services SDG provides information systems that are of common nature including those related to finance, procurement, contracts, stores, human resources, maintenance, project management, email and electronic correspondence services, eArchiving, ePay, portal, connection, electronic integration and decision support systems. These services are provided to all Dubai Government Entities.

One example of these services is the central eComplain System, **www.ecomplain.ae**, which is designed to raise the level of performance in Dubai's public sector and is the first of its kind in the region. The system is an electronic platform that enables users to complain about public services. This guarantees the reception of their complaints at 27 government departments that share the system. As an administrative system, eComplain is based on the best international practices and includes the mechanisms of: receiving complaints, studying them, dealing with them, measuring their impact, and benefiting from them through ultimately enhancing governmental performance while protecting the privacy of the complainers and the discretion of their information.

Box 6 – Screenshot of Smart Dubai's eComplain system (Dubai Smart Government, 2016)

Box 7 – Smart Technology for Civil Engagement- Mohammad Bin Rashid Smart Majlis (Smart Dubai Government, 2016)

The Mohammed Bin Rashid Smart Majlis, launched and managed by The Executive Office of His Highness Sheikh Mohammed, is the largest smart and integrated platform in Dubai for public engagement. The platform, which connects 30 entities, has been designed to receive and process suggestions, comments, and ideas from the general public.

The Mohammed Bin Rashid Smart Majlis offers any individual the opportunity to present innovative ideas that can contribute to the development of Dubai and enhance its attractiveness in various fields. The Smart Majlis also provides the public with the opportunity to give feedback on whether there are any defects or faults in various facilities such as parks, beaches and roads, thus enabling competent authorities to identify them and adopt all measures necessary to help maintain the good image of the city and its public facilities.

The Smart Majlis also supports large-scale public brainstorming exercises, wherein members of the general public can respond to ideas or challenges posed by His Highness Sheikh Mohammed. The platform allows the public to actively engage and interact with the government, and is a significant contribution to boosting public engagement opportunities in Dubai.

3.4.5.   Dimension 5: Quality of Life

Dubai has identified a high quality of life and excellent living conditions as core objectives for the City. One mechanism for achieving this is through improved social welfare: by providing various public services aimed at maintaining an advanced level of social and economic stability. This includes providing infrastructure and municipal services, education, safety and healthcare services to Dubai's citizens (Government of Dubai, 2015). Smart Dubai is working with several entities on the introduction of ICTs to promote efficiency in pertinent city services that improves quality of life (for example, education, health and safety).

In Education, Dubai aims to improve the quality of private schools and higher education institutions through various programs conducted by the Knowledge and Human Development Authority (KHDA). It is important to note that the public schools are under the jurisdiction of the Ministry of Education. Most schools have computer labs or Bring Your Own Device policies. KHDA has adopted an outcome-based approach and as part of its school inspections, assesses the ability of students to be independent learners and use learning technologies effectively. As schools develop critical thinking and problem-solving skills students can more readily find things out for themselves using a range of technological, and other, resources.

Dubai also participates in The *Mohammed Bin Rashid Smart Learning Program* (MBRSLP). Launched in 2012, it is aligned with UAE Vision 2021 to become a knowledge-based economy through the integration of technology in education. The UAE is investing heavily to bring the

latest technology to schools throughout the Emirates to encourage the development of creativity, analytic thinking, and innovation. The MBRSLP aims to shape a new learning environment and culture in federal schools through the launch of "smart classes" that will provide every student with an electronic tablet and access to high-speed 4G networks by 2019 (MBRSLP, 2016).

Regarding health services, Dubai Health Authority (DHA), defines health policies in the Emirate. DHA is introducing ICTs in their operational processes and recognizing the importance of e-health, *"as an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies"*. DHA aims to ensure that all hospitals in Dubai eventually adopt the electronic model, which will facilitate better healthcare services to the community through tele-medicine and tele-assistance services (Dubai Health Authority, 2016).

At present, Smart Dubai and Dubai Health Authority are working on the definition of an assessment framework and KPIs to evaluate the impact that ICTs will have in transforming their health sector. Dubai Health Authority's expertise in this field, and in the adoption of new ICT technologies in health services provision, has been valuable to the smart sustainable cities KPI assessment process.

Dubai Police (DP), which manages Dubai's security and safety issues, uses the highest and most precise technologies in performing its duties and functions. Dubai Police is the first police force in the Arab world to introduce smart digital services to facilitate all standard transactions and procedures. This enables Dubai Police staff, residents, and visitors to conduct police services efficiently and rapidly (Smart Dubai, 2016). Dubai Police is also part of the Dubai Open Data Committee, and contributes to the development of effective policies and programs on child online protection, privacy, etc. Qualitative and quantitative measures are required for evaluating the development of services for city safety and security. Dubai has the capability to collect numerical data related to the use of technology for city safety and management.

See Box 8 and Box 9 for more on how Dubai manages safety through ICT usage.

Box 8 – City safety management through ICTs (Smart Dubai, 2016; Dubai Police, 2016)

Dubai's government officials use ICTs to optimise internal processes and to gather real time information on citizens' feedback on incidents occurring in the city. The Dubai Police app gives access to information on smart safety services, traffic and accidents control, incidents reporting, police stations information, etc.

This solution aims to be intuitive for citizens, and allows them to play an effective role in the community by contributing towards safety and& security through the newly added Police Eye service and other apps. Some of these services and apps are as follows:
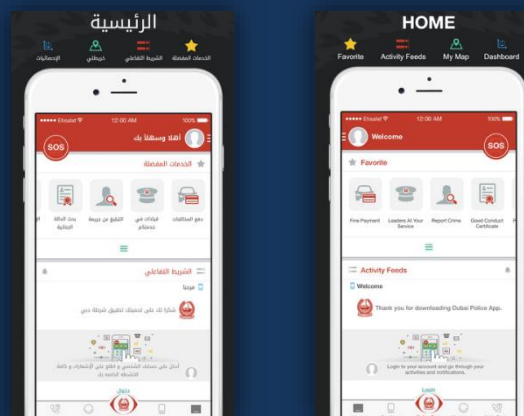
Dubai Police APP: Dubai Police APP has been launched with the following new features:

- Availability in 6 languages

- Smart Notification feature.

- Business Profile option

- PB board: Users of Dubai Police Smart Applications can access the major smart services, through the Keyboard, without the need of logging into the application. By simply, pressing the Dubai Police Logo and choosing the service required, such as payment of traffic fines, certificate of criminal record, etc, users can access the required services.

- (IMessage): you have access to Dubai Police Smart Application, through the Messages Application (iMessage), without the need to log in to the Application.

- Smart Police Station services: Smart Police Station services available since most of its services are fully smart and automated. No need for human interaction in the backend, its auto generated from the system within (10 min).

- Access to this app is possible through Smart Watches.

Traffic Fine Payment and suggestion (SIRI)

- Dubai Police Application has been linked to some of the services offered by the Smart Virtual Assistant (Siri), available on iPhone devices. User(s) can send suggestions and remarks and pay for violations by the special voice commands for (Siri), without opening the application. Dubai Police is one of the first establishments, in the region, to develop smart services that fit in with one of the most important characteristics that depend on artificial intelligence, which is (Siri) feature.
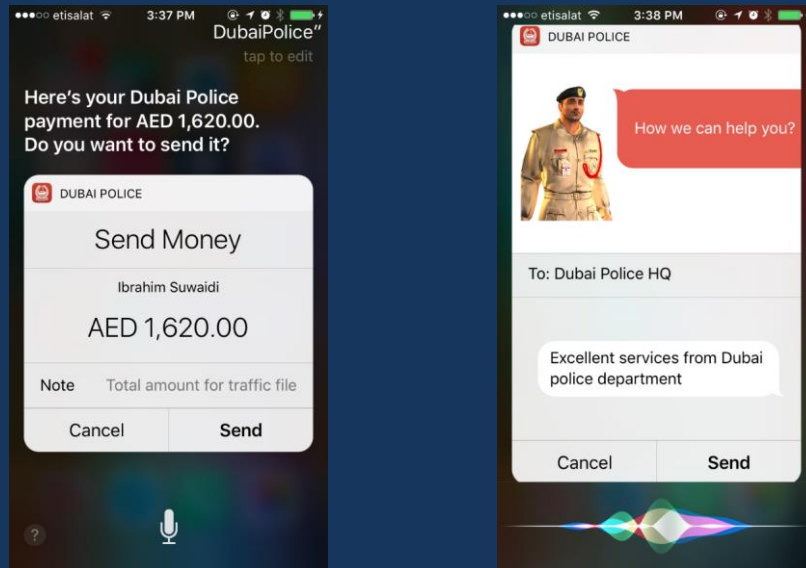
Minor Accident Reporting: Minor Accident reporting allows residents to take a picture and send to the system by mobile phone.

This is a service (app) launched by Dubai Police for reporting small and minor accidents on the streets.

Small Accident reporting allows for users to take a picture and send them to the system using mobile phones. Additionally, the report of the accident can be sent to the Police and action would be taken based on the picture and facts submitted.

This service allows drivers involved in a minor or moderate accident to obtain an accident report for submission to their insurance company. Types of traffic accidents for which reports can be issued include: a collision between two cars without injury and/or colliding with property without injury.

Police Eye: The service is used to report any suspicious activity, easily, by locating the reported location/area, on the map. Utilizing this service, users can contribute to the security of Dubai.

Dubai Police board: This platform has all of Dubai Police smart applications. It can be used without logging into the applications

Box 9 – Dubai Civil Defence- City Dashboard (Smart Dubai Government, 2016)

In order to achieve the vision of His Highness Sheikh Mohammed Bin Rashid Al Maktoum, UAE Vice President and Prime Minister and Ruler of Dubai, to transform the city of Dubai to a Smart City, Dubai Civil Defence has launched many smart applications to alter the way services are provided to their customers and the public. Dubai Civil Defence has now added another new service to its smart services offering by launching "Dubai Life Safety Dashboards". These dashboards provide reliable and accurate information to the Dubai Civil Defence operations and the building owners.

The Dubai Life Safety Dashboards provides Dubai Civil Defence access to real-time and historical information related to their KPIs and operational data, allowing them to make optimum use of their assets and services, and also to make the most efficient use of their time. By pulling together data from major data sources including links to a variety of existing applications — the Dubai Life Safety Dashboards provides interactive data visualizations to Dubai Civil Defence.

City Dashboard provides the user with the information at a city level regarding Dubai's Life Safety.

3.4.6. Dimension 6: Physical infrastructure

Dubai has prospered due to solid investment in transportation, telecommunications, energy, and industrial infrastructure. International businesses are attracted to Dubai's network of industrial 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. These services and entities aim to deliver efficient services throughout the Emirate (Government of Dubai, 2015).

Infrastructure in Dubai is managed by different entities, Roads and Transport Authority (RTA) for transportation and mobility, Dubai Electricity and Water Authority (DEWA) for water and electricity infrastructure and Dubai Municipality (DM) for urban development infrastructure.

These entities work with Smart Dubai to assess the impact of ICTs on the City`s sustainability and smartness. They provide information and data required to build KPIs, reflecting the effectiveness of the policies and programs that are transforming service infrastructure into smart-services delivery. For example, DEWA relies heavily on ICTs to improve service provision and engage citizens towards saving energy and water. Dubai Municipality has initiated several ICT projects to manage and control part of its municipal services such as waste, food safety control, testing of products, environmental management, etc.

Dubai works with the Supreme Council of Energy (DSCE) to define policies and measurement frameworks for energy, GHG emissions, and climate change targets in the Emirate. Dubai's energy integration and carbon emissions reduction policies are designed to drive energy efficiency of the transportation, building, energy, and water sectors.

Water management infrastructure in Dubai is very challenging for sustainability goals because most of Dubai's water is sourced from the sea, and water desalination and treatment are very complex. DEWA has integrated ICTs in the water provision service infrastructure, generating important efficiencies in the service delivery. Based on this experience, Dubai Municipality can make use of new opportunities that are emerging to expand the use of ICTs for wastewater and drainage management of the city.

Dubai's infrastructure supplies energy to buildings, households, industries and the service sector. The Dubai Carbon Abatement Strategy 2021 has specific greenhouse gas reduction targets for each sub-sector. For example, power and water savings in the built environment contribute to the overall carbon emission targets for the overall energy and water sector through Demand Side Management programmes. These targets then contribute to Dubai's yearly city targets. Another example is the reductions realised through operational efficiency programmes in power and other plants. Many of these improvements are the result of enhancing controls and deploying smarter and more efficient infrastructure within these plants.

Since 2014, Dubai has been rolling out smart meters for energy and water customers for the whole emirate. Dubai residents can also generate their own electricity using solar panels that feed extra energy to Dubai's power grid. This step will gradually transform the consumers to active prosumers: a term used to describe consumers that generate part of their own energy consumption, in the context of Dubai`s smart grid initiatives.

The Roads and Transport Authority (RTA) manages transportation and mobility infrastructure in Dubai and has been introducing ICTs to improve efficiency and sustainability of the transportation sector. RTA has an effective measurement framework to assess the efficiency of Dubai's integrated transportation and mobility infrastructure. Dubai has reported on most of ITU's transportation key performance indicators, suggesting a strong integration of ICT's in Dubai's transportation sector.

Box 10 illustrates how ICTs are integrated across Dubai's transportation and mobility value chain.

**Box 10 – Using ICTs in the transport and mobility value chain
(Dubai Roads and Transport Authority, 2016)**

Dubai has been investing in new and smart technology as part of its contribution towards achieving the government's vision of becoming the world's smartest city. Dubai includes ICTs in all value chains to improve service provision, including the introduction of technologies to improve such issues as traffic management, parking management, and public transportation.

In 2015, RTA launched 10 applications for smart phones transport users that provide easy and instant access to its services. While developing the applications, RTA considered different user categories, including: driver and car owner services; public transportation services, and business and corporate services. As of 2016, the city provides 173 smart services contained in these applications to users, enabling them to access RTA services from anywhere, at any time, and deliver a superior user experience. It also relies on the utilization of the latest technology in social-media interaction-analysis and customer relationship management tools.
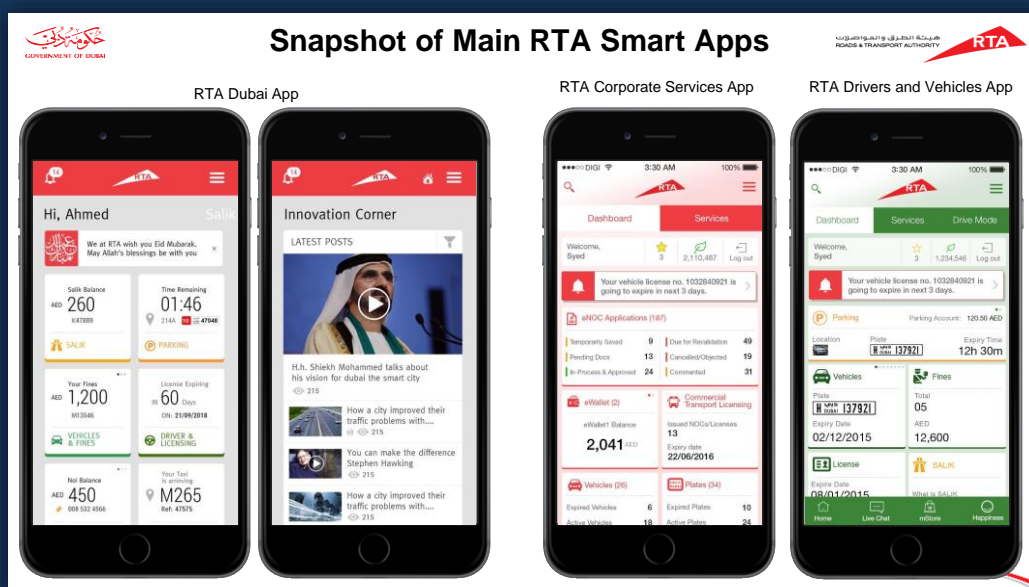
Dubai's Supreme Council of Energy leads the Dubai Green Mobility Initiative, which promotes the use of hybrid and electric vehicles (EVs). Launched in 2016, the Dubai government aims to replace 10% of their yearly-procured vehicles with hybrid and EVs. This initiative creates a market for hybrid and EVs, thereby contributing to lower greenhouse gas emissions and enhancing air quality by providing cleaner modes of transportation for Dubai's inhabitants.

Dubai Municipality manages infrastructure in the building environment. Dubai has demonstrated a leading role in managing energy consumption and enhancing energy efficiency measures in buildings. For example, Dubai has a Green Building Code to ensure that construction and design standards of new buildings adhere to principles of maximizing energy and water efficiency. It also implemented a green construction code that will help effective utilization of in energy and natural resources. Dubai is also among the first in the region to set up a market for Energy Service Companies (ESCOs), which are companies that retrofit old buildings based on innovative business models. The Dubai Government has set a target to retrofit about 30,000

buildings by 2030 starting with government buildings. This initiative will not only achieve power and water savings, but it is expected to enhance occupant productivity and provide a more ideal working environment within government buildings. Energy intensity mapping will result in the development of a database to monitor energy consumption footprint (kWh/m^2) in buildings. This project is currently on going and a pilot software programme to manage collected data is under development.

4. Opportunities for Improvement: What have we learnt?

4.1. Best practices in aspiring smart sustainable cities

After reviewing the main smart city related activities in Dubai under each dimension, this section highlights a few of the best practices. These best practices from Dubai illustrated in this section will help gain an in-depth understanding of "the process" of formulating measures for smart city development, which can assist aspiring smart cities in similar situations.

This section also lays out some suggested actions for cities which are on similar smart city trajectory. It is foreseen that implementation of such actions will improve the feasibility, relevance and applicability of the KPIs to Dubai as well as to other aspiring smart sustainable cities.[3]

This Section will also help ITU initiate the process of benchmarking smart city practices for the Global Smart Sustainable City Index.

4.1.1. Dimension 1: Information and Communication Technologies

Measures Adopted by Dubai	Suggested Action for other aspiring smart sustainable cities (based on Dubai's experience)
Dubai has introduced a secure and reliable ICT infrastructure for the provision of urban services to its citizens.	City administrators are encouraged to incorporate ICTs into their existing urban infrastructures before commencing their smart city journey, with the aim of upgrading their current services.

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[3] Implementing these best practices need not guarantee high level of verifiability of the data provided given the dynamic and individualistic nature of urban systems. However, the best practices in this Section are certainly expected to improve the overall applicability of the KPIs in emerging smart cities.

Other actions needed for Dubai and other aspiring smart sustainable cities

EMF management and control

Cities should reinforce their collaboration with relevant entities to incorporate EMF management policies in city network development activities in order to provide information to citizens and to define an assessment framework to facilitate EMF monitoring.

Cities should consider implementing ITU's international standards (ITU-T Recommendations) on EMF management and control, taking as reference the world carried out by ITU-T Study Group 5 on "Environment, Climate Change and Circular Economy".[2] These ITU-T Recommendations include K.52, K.74, K.78, K.87, K.100, K.113, K.115.

In addition, awareness and information campaigns should be developed by the different urban entities. ITU has developed a web-based EMF Guide and mobile application to be used by cities, (ICT sector, citizens, etc.), with information on this matter that could be taken as reference.

Child online protection

Child Online Protection (COP) should take centre stage in smart sustainable cities. It is suggested that aspiring smart sustainable cities manage their COP programme under a specific initiative in coordination with all stakeholders involved. This will allow for alignment with other cities and countries' initiatives and will highlight the relevance of child protection in the ICT realm.

ITU has prepared Guidelines for Child Online Protection in collaboration with COP partners. These guidelines establish the necessary foundation for a safer and more secure cyber world in smart sustainable cities. The guidelines are meant to be adapted and adopted by the concerned stakeholders including city administrators.

Privacy and data protection

Compliance with international standards on privacy and data protection should be sought by aspiring smart cities.

ITU, within their Connect 2020 Targets, has established a target on Cybersecurity, which states that Cybersecurity readiness should be improved by 40% by 2020. Municipalities wishing to establish their own smart cities should actively participate and contribute to the work of ITU-T Study Group 20 and the Connect 2020 targets of ITU.

4.1.2. Dimension 2: Environmental Sustainability

Measures adopted by Dubai	Suggested actions for other aspiring smart sustainable cities (based on Dubai's experience)
ICT-based technologies have been introduced for the delivery of water in Dubai. The city also has an effective smart metering system to monitor water consumption across the city.	City administrators are encouraged to integrate ICTs into their water management systems for the collection, treatment and distribution of water to their residents. Using of ICTs for this purpose will also help improve the efficiency of water distribution system and assist in the provision of potable water especially in developing countries.
Dubai has adopted the "Integrated Energy Strategy" to increase the proportion of clean energy sources (including renewable energy) in their urban energy mix.	City leaders should track energy usage, with a view to increase the use of renewable energy sources to ultimately reduce the burden on existing fossil fuels. This will also help limit the greenhouse gas emissions which are produced by burning fossil fuels.
Dubai has introduced the Carbon Abatement Strategy 2021 to reduce CO_2 emissions	Urban stakeholders should focus their efforts on reducing the carbon footprint of their city (in line with the COP-21 targets and SDG13). This can be achieved by introducing ICT-based monitoring systems to identify sectors with the highest emissions.

Other actions needed for Dubai and other aspiring smart sustainable cities

Use of ICTs for the environment

Urban stakeholders should work on the development of internal processes to assess the impact of the use of ICTs for environmental quality monitoring in the city. In addition, city leaders should work on the promotion of the use of ICT based technologies to improve solid waste collection processes and support real time monitoring of air quality, noise generation and other environmental parameters.

Reducing GHG emissions

The use of ICTs to reduce city GHG emissions, requires the definition of integrated policies and the analysis of impacts of ICT-based projects. The transport and building sector, are among the major contributors of GHG emissions in all major cities of the world. Aspiring smart cities should continue working on the analysis of energy consumption and emissions generation sources in order to identify opportunities for reduction using ICTs. This will help propagate the importance of the issue in the global sustainability agenda and assist in bringing down the associated management costs in the building and transport sector.

Cities' environmental performance

To better evaluate environmental aspects, cities should also examine their environmental performance together with a joint evaluation of the environmental KPIs included in the infrastructure dimension of the KPIs given in ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. An analysis of city infrastructure and its impact on urban environmental quality should be carried out. This will lead to a better understanding of the key environmental challenges of the city and to the identification of new innovation opportunities that could enhance the use of ICTs for environmental sustainability.

The New Urban Agenda

The United Nations Conference on Housing and Sustainable Urban Development (Habitat III) was held from 17 to 20 October 2016 in Quito Ecuador. The Habitat III successfully concluded with the adoption of the New Urban Agenda. This New Urban Agenda is expected to serve as the de-facto urbanization guide for the years to come. After much deliberation, given the potential of ICTs in driving urbanization, the concept of "smart cities" was duly included in the New Urban Agenda. Cities wishing to transition to a "smart" and "sustainable" city are called to abide by the guidelines and concepts set forth by the New Urban Agenda to ensure that urbanization targets for the next 20 years are met.

4.1.3. Dimension 3: Productivity

Measures Adopted by Dubai	Suggested Action for other aspiring smart sustainable cities (based on Dubai's experience)
Dubai has introduced SAAD, an e-service with cognitive computing technology to support business licensing and registration and to create an atmosphere of entrepreneurship.	City stakeholders are encouraged to introduce e-platforms which support business innovation. These e-platforms will help attract more investments and promote job creation.
Smart Dubai and DED work together to assess the impact of ICTs on economic growth to promote transparent reporting on economic initiatives.	City leaders should ensure that ICTs facilitate a defined economic growth agenda and enable effective reporting on economic parameters.

Other actions needed for Dubai and other aspiring smart sustainable cities

Open Data

Aspiring smart cities should promote the use of open data and reinforce existing open data platforms to allow private sector firms and entrepreneurs to develop applications and solutions to address city challenges.

Smart city progress

Cities wishing to monitor their smart city progress should work with the relevant governmental entities to determine the best ITU SSC KPIs to assess the impact of ICTs in city economy, productivity and innovation capabilities. Dubai's experience in this area, will also contribute to the KPI standardization processes on smart cities, economic growth and sustainable development, helmed by ITU together with other UN agencies and programmes.

ICT innovation

ITU Connect 2020 Agenda has defined particular targets to promote ICT innovation in the changing telecommunication/ICT environment. (ITU, 2016). Countries are called to promote a Telecommunication/ICT environment conducive to innovation and built upon effective partnerships of stakeholders involved. To this end, Dubai and other aspiring smart cities are called to align their smart city strategies to the Connect 2020 Agenda on ICT innovation and to share their experience in smart cities innovation projects with other cities and countries.

4.1.4. Dimension 4: Equity and Social Inclusion

Measures Adopted by Dubai	Suggested Action for other aspiring smart sustainable cities (based on Dubai's experience)
Dubai has launched the DubaiNow app which allows for access to 2000 government services. This app was introduced with the aim of meeting the needs of the citizens and ensuring their happiness.	Cities are encouraged to develop a common e-platform on which citizens can access all the public services/information offered including traffic information, weather details, online payments for utilities etc.
eComplain System was introduced in Dubai for citizens to regularly provide feedback on the public services.	Cities are suggested to establish a feedback or grievance portal which allows for citizens to highlight their personal experiences related to a certain services or to provide inputs for its improvement.
Police Eye in Dubai is being used to report any suspicious activity, by locating the reported location on the map. Through this, users can contribute to the security of Dubai.	Cities may wish to review whether similar services may be implemented, through which illegal and unauthorized activities can be easily tracked.
Dubai's Minor Accident reporting allows residents to take a picture and send to the system using their mobile phones. This service (app) has been launched by Dubai Police for reporting small and minor accidents on the streets.	Aspiring smart cities can take a leaf out of Dubai's book and can launch an app through which citizens can themselves report crime and collect evidentiary support.
Dubai has introduced several Smart SOS (Save our Soul) and wearable devices. Dubai has various service apps with location-based "Fast Emergency Alert" function. For example: There is a smart watch app that allows the user to ask for help. The app uses GPS information to provide the location of the user. These services are for citizens and residents of Dubai. The wearable and Smart SOS devices also have a new feature for the visually impaired, using which comments or complaints can be sent through the Dubai Police Application.	Cities are advised to promote the launch of easily accessible and portable smart devices which are children friendly to promote public safety.
Dubai's "Drive Mode" feature is both smart and innovative. It works only when the user is in drive mode. The App is capable of sending audio notifications about accidents near the user's location.	Traffic congestion is a major problem in most urban centres. By introducing an app to maneuver through traffic and reduce any incidences of accidents, aspiring smart cities can curb this issue.

Measures Adopted by Dubai	Suggested Action for other aspiring smart sustainable cities (based on Dubai's experience)
Dubai has launched the "My Community…A City for Everyone" in 2016, which aims at turning Dubai into a disability friendly city by 2020. The objectives of this initiative aim to promote equal opportunities, drive social cohesion, build social capital and minimize social exclusion.	Aspiring smart cities must also cater to the differently abled individuals of society by introducing ICT-based innovations including apps and other services to foster and ease their involvement in daily urban activities.

Other Actions needed for Dubai and other aspiring smart sustainable cities

Projects and city services

Cities should focus efforts on incorporating projects and city services that could enable the empowerment of women and integrate groups of people who are at risk of exclusion; such as disabled individuals, elderly people, etc. The need of assessment frameworks which includes KPIs such as the Gini coefficient and gender income disparity will facilitate this process and allow alignment with other cities in the journey to become smart and sustainable.

The Gini coefficient is defined as the relationship of cumulative shares of the population arranged according to the level of equalized disposable income, to the cumulative share of the equalized total disposable income received by them

City services

Cities should work on the development of measurement frameworks to assess the e-transformation of private solutions that could impact city services provision to excluded groups and women. For example: private e-commerce transactions, e-payment transactions, private e-education systems, private cultural e-initiatives.

4.1.5.   Dimension 5 Quality of Life

Measures Adopted by Dubai	Suggested Action for other aspiring smart sustainable cities (based on Dubai's experience)
The Mohammad Bin Rashid Learning Programme in Dubai focusses on integrating technologies into the existing education system. This Program was established to further advance the United Arab Emirates' education system into the next phase of development through the application of world class teaching techniques and advanced technology.	City leaders are encouraged to introduce e-learning systems to familiarize citizens with technologies. These e-learning systems will also allow for the imparting of knowledge in remote areas which do not have proper schooling systems.
Dubai is working towards the introduction of electronic models in their hospitals which will facilitate better healthcare services to the community through tele-medicine and tele-assistance services	City administrators should introduce technology-based medical systems through which hospitals can manage their medical records and offer their services remotely through tele-medicine channels.

Other Actions needed for Dubai and other aspiring smart sustainable cities

ICT-based healthcare systems

Dubai's experience in ICTs and health services provision on a city level, would be of great value to contribute to global KPI standardization efforts in this matter. Dubai and other cities with effective ICT-based healthcare systems, are called to contribute to ITU standardization process for e-health and IoT based-services delivery and KPIs assessment frameworks, mainly included in the work carried out by ITU-T Study Group 20 on IoT and Smart Cities and Communities.

International metrics and techniques

Cities should collaborate with their entities to define common metrics and techniques to evaluate the sustainability and smartness of their existing education programs. These metrics should be internationally recognized and allow for alignment with other cities. The existence of programs in this area will help credible smart cities to be positioned as a reference for other cities of the world.

4.1.6. Dimension 6: Physical Infrastructure

Measures adopted by Dubai	Suggested actions for other aspiring smart sustainable cities (based on Dubai's experience)
RTA has introduced ICTs into Dubai's traffic system for parking management, traffic circulations and public transport.	City administrators should utilize ICTs to manage their traffic systems and reduce vehicular burden on the road by introducing effective public transport mechanisms.
Dubai has adopted the Green Mobility Initiative to promote the use of hybrid and electric vehicles which consume less fuel and reduce greenhouse gas emissions.	City leaders should promote the use of hybrid vehicles to reduce the carbon footprint. Cities may also consider introducing hybrid vehicles into their public transportation systems.

Other actions needed for Dubai and other aspiring smart sustainable cities

Use of ICTs for transport efficiency and sustainability

The assessment of the effective use of ICTs for transport efficiency and sustainability has been a challenge for cities and the ICT sector itself. RTA experience in ICT-based services for transport, should be taken as reference for future smart sustainable KPI standardization efforts. Aspiring smart cities should consider working on the introduction of energy and carbon efficiency metrics in their ICT-based sustainable transport projects and programs.

Smart water management

Cities should continue working towards the optimization of the whole city water cycle, including the water provision, storm water and waste-water management services. An integration of energy-water policies would be beneficial to aspiring smart cities. Assessing the impact of the use of ICTs in terms of resource efficiency is critical to ensure a sustainable water management model in the city.

Cities can consider the evaluation of the impacts of ICT-based water management solutions, taking as reference the guidelines and examples developed by the ITU Focus Group on Smart Water Management*. Currently smart water management topics are explored in detail within ITU-T SG20 on IoT and Smart Cities and Communities. Smart water management (SWM) in cities seeks to alleviate challenges in the urban water management and water sector through the integration of ICT products, solutions and systems in areas of water management and sanitation, as well as storm water management* (ITU, 2016)*.*

4.2. Methodological improvement for the data collection process: Insights for future pilot projects

Dubai has embraced ICT-driven urban transformation to meet its social, financial, and sustainability goals as outlined in the UAE's Vision 2021. This smart city transformation integrates technologies and business/operational processes for the improvement of the lives of its people.

As an advanced technology driven city, Dubai was able to report upon a meaningful number of the ITU smart sustainable cities KPIs from the total of 108 KPIs defined in Recommendations ITU-T L.1601 and ITU-T L.1602 (78 core and 30 additional).

Annex 1 presents the summary of the KPIs reported and verified by Dubai during 2014 (the first collection period). The analysis presented in the Annex is only for the first year of the pilot project. As the pilot project continues, these inferences and findings may be altered in keeping with the situation in Dubai.

During the KPI collection and verification process, it was also acknowledged that some data that was needed to measure the KPIs was not traceable or accounted for by the participating agencies in Dubai for the stipulated period. However, on a positive note, the preliminary results of the assessment and verification processes for the first year revealed that Dubai had a proper understanding of the aim of KPIs that involved focusing on the use of information communication technologies to improve urban services. Based on this experience, Box 11 summarizes the key actions and policy recommendations to improve the KPI Collection phase for future cities aiming to collect data for their smart city assessment and verification.

Box 11 – Key policy actions and recommendations to improve the KPI collection process for cities aiming to become smarter and more sustainable

- Cities should define and continually update their city profile and boundaries in order to facilitate the scope of the KPI analysis to a homogeneous city model.

- Cities should reinforce the process of clarification of the boundaries of the KPIs reported on a national or city level to avoid data deviations.

- Cities should work in coordination with different entities and facilitate interaction between those institutions responsible for KPIs that could influence a particular dimension or sub dimension.

- Cities should work closely with the relevant entities to ensure that the aim of the KPI is mutually understood. This will help with the overall collection process and improvement of future KPIs.

- Cities should suitably adapt the ITU KPIs collection process to their requirements and procedures and to the mechanisms used by the entities to collect primary data.

- Cities should develop and implement internal quality control mechanisms to ensure the consistency of the data reported.

- Cities should identify and differentiate the data sources and data owners of the different KPIs and establish required procedures. This will allow for the identification of data gaps, avoid duplication, and help improve the data quality.

- Cities should determine the frequency of data collection for the KPIs and try to standardize and coordinate the deadlines with the different entities for the reporting process.

- Cities should define a general protocol to standardize the process of data collection based on surveys. Cities interested in initiating the KPI data collection process are also encouraged to collect all KPIs on an annual basis, with the exception of KPIs that are collected every two years in consideration of the survey collection period.

- Cities may wish to establish a "lessons learned process" with inputs from all entities involved to review and improve the data collection process.

- Cities should consider using multiple data sources internally, which can yield a more complete picture for the KPI verification process and also build credibility for the smart city project. By collecting information from multiple sources, it is also possible that one source of data will compensate for a weakness in another source.

- Cities should establish the initial process for defining smart-sustainable city targets and utilize the KPIs of Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602 as referential inputs for the same.

4.3. Areas meriting closer attention: How can the KPIs be improved?

An evaluation of the KPIs characteristics was also carried out in order to guarantee coherence, alignment and comparison with the KPIs assessment process in cities elsewhere. The desired characteristics of these KPIs are described in Box 12.

Box 12 – ITU Smart Sustainable Cities KPIs characteristics (ITU , 2016)

- The KPI name, concept clarity, and the target level of the aspect that is to be measured have been taken into account.

- The need to maintain consistency of the calculation formula to generate the KPI based on the primary data collected was highlighted. The variables of the formulas should match the aspect to be measured. It has to have mathematical coherence. The reported values for the baseline year should be aligned with the unit of measure defined for the KPI.

- The frequency of the KPI calculation and measurement should be consistent.

- The baseline year and the measurement frequency of the KPI reported should have sufficient mechanisms available to guarantee that the primary information to generate the KPI is correct.

- The KPI should be measurable if all the primary information to generate it is available.

- The KPI should be relevant and should measure what is expected to be measured i.e. the use and impact of ICTs on cities` efficiency and sustainability.

This pilot project in Dubai has revealed certain areas for improvement in the KPI framework developed by ITU in the Recommendation ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. Accordingly, this section will highlight some suggestions for improvements in the KPIs which Dubai submitted to Advisory Board for Smart Sustainable Cities for the development of the Global Smart Sustainable City Index and for the future review of the existing KPIs.

- It was noted that there was considerable overlap between some KPIs between the ICT dimension, Environmental Sustainability dimension and the Physical Infrastructure dimension. These KPIs should be slotted more appropriately under the different dimensions to remove repetitions and to avoid making cities measure the same areas related to different indicators.

- Certain KPIs were not adequately defined for Dubai to be able to collect the required data for its verification. Dubai has provided inputs to ITU on each KPI to facilitate improvements in their definitions and applicability. These recommendations should be give due consideration by the U4SSC members when refining the KPIs.

- Some KPIs included data elements that are not collected systematically even in developed countries. These KPIs tended to be aspirational and thus the gap between theory and practicability/feasibility needs to be bridged when refining the KPIs. In this regard, it should be ensured that the indicators are feasible to measure, consistent and comparable over time.

- The existing KPIs do not seem to take into account international agreements and targets including the Sustainable Development Goals and COP-21 targets. This aspect should be altered when the KPIs are sent for revision.

Before initiating the data collection process for the KPIs, cities may consider adopting an "applicability checklist" developed by ITU which can provide an overview of which KPIs can be easily collected within their territories. This checklist will highlight the key areas which require improvement in the city before the verification process is conducted.

As the first year of the pilot project in Dubai has come to a close, there is a realization that Dubai and other cities need a method for comparing and contrasting their smartness and sustainability progress and performance against their local, regional, national and global peers.

In response, the ITU and UNECE have led the formation of the United for Smart Sustainable Cities (U4SSC) initiative (see Box 13) which will further develop these KPIs. Subsequently, these KPIs will serve as a key input to a global Smart Sustainable Cities Index and assist in the achievement of the SDGs.

Box 13 – Introduction to the U4SSC initiative

United for Smart Sustainable Cities initiative

The United for Smart Sustainable Cities (U4SSC) initiative was launched by ITU and UNECE in May 2016. The U4SSC advocates for public policies to encourage the use of ICTs to facilitate and ease the transition to smart sustainable cities. This initiative is known to be the first global initiative exclusively for smart sustainable cities. Currently, the U4SSC enjoys the support of 16 other UN agencies and programmes. Participation in the U4SSC is free of charge and is open to all interested stakeholders.

The UN agencies and programmes represented are:

- International Telecommunication Union (ITU)
- United Nations Economic Commission for Europe (UNECE)
- Convention on Biological Diversity
- Economic Commission for Latin America and the Caribbean (ECLAC)
- Food and Agriculture Organization (FAO)
- United Nations Convention to Combat Desertification (UNCCD)
- United Nations Economic Commission for Africa
- United Nations Environment Programme (UNEP)
- UNEP Finance Initiative
- United Nations Framework Convention on Climate Change (UNFCCC)
- United Nations Human Settlements Programme (UN Habitat)
- United Nations Industrial Development Organization (UNIDO)
- United Nations University (UNU-IAS)
- UN Women
- World Meteorological Organization (WMO)
- World Trade Organization (WTO)

The activities of the U4SSC are conducted through the following working groups:

- **Working Group 1:** Setting the Framework
- **Working Group 2:** Connecting Cities and Communities
- **Working Group 3:** Enhancing Innovation and Participation

The work of the Advisory Board for Smart Sustainable Cities also falls under the U4SSC. This Advisory Board is tasked with the responsibility of refining the existing ITU KPIs on smart sustainable cities to achieve the SDGs.

The Advisory Board consists of members from the private sector, public sector, NGOs and UN agencies. Membership to the Advisory Board is by invitation only.

4.4. Practical insights from ITU's KPI process in Dubai

Smart Dubai has aligned its smart city vision with the needs of its residents and the new digital paradigm. One of Dubai's most valuable assets observed during the first year of the pilot project, is the number of high-level professionals trained in smart city concepts.
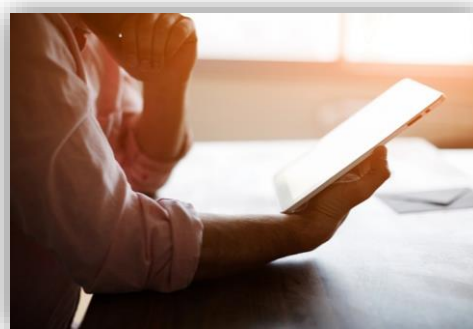
The Smart Dubai vision, together with different technological and governance programs implemented in the city, makes Dubai the ideal laboratory to assess the impact of ICTs in cities that aim to be smart and sustainable. The first year has presented ITU and Dubai with novel ideas on the planning for the second year of the pilot project and has significantly boosted their learning curve. With the subsequent revision of the KPIs, both ITU and Dubai will be better placed to cover the requirements for all the KPIs. The second round of data collection and verification for the KPIs is also expected to provide a broad baseline for the Global Smart Sustainable City Index for other cities. To this effect, Dubai can also use the findings from the second year to expound on the strengths, monitor perceived improvements and set the basis for future action within their Smart Dubai initiative.

Dubai`s experience based on this pilot project to test the KPIs should be given due consideration for the future standardization efforts made for ITU's Smart Sustainable City KPIs. Given the significant strides Dubai has made in the smart city realm, Dubai could be invited to share their expertise and experience on KPI assessment frameworks with other cities (especially in developing countries).

As Dubai is one of the world's first cities to assess its urban efficiency using the KPIs for Smart Sustainable Cities included in Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602, it would be advantageous to receive inputs from Dubai's pilot project for the development of the Global Smart Sustainable City Index, which will serve various other cities across the globe with their smart city transitions. The work of the U4SSC will also greatly benefit from inputs received from the Dubai pilot project. These inputs will also facilitate the standardization process of the KPIs within ITU-T Study Group 20 "Internet of Things and Smart Cities and Communities".

To further the global smart city ambitions, the pilot project conducted by ITU and Smart Dubai has identified a number of key aspects and actions that emerging smart cities can examine and implement for the continuous improvement of their urban systems and the delivery of services within their respective smart city visions.

Based on the first year of the pilot project, this section includes suggestion from ITU that will shape the global smart sustainable cities agenda and will assist cities in starting their smart city voyages.

- A major lesson learned from Dubai, is the importance of the leadership role of Smart Dubai in ensuring that all entities work collaboratively on the smart city transition and the data collection and subsequent verification process for the KPIs. In line with this, aspiring smart cities and their entities should collaborate on the introduction of

assessment frameworks that evaluate impacts of different services, and their overall contribution to the city vision. The aspiring smart city and its entities are also advised to work together to build a robust and homogeneous city profile and baseline, aligned with the strategic pillars of their respective city (dimensions), governed by a central body which could take on the leadership and monitor the transition.

▪ It would be beneficial if aspiring smart cities documented the KPI collection process to identify and differentiate the data sources and data owners of the different indicators, subsequent to the standardization of smart sustainable city KPIs. Interested cities can use the ITU KPI-Collection Guide and adapt it to ground realities and its own collection process.

▪ City stakeholders should consider establishing their own smart city dimensions based their existing governance structure and the dimensions set by the Recommendations ITU-T Y.4901/L.1601 and ITU-T Y4902/L.1602.

▪ Cities interested in implementing the KPIs for SSC should work with all entities to establish a timeline for data collection that can ultimately be standardized. This is being suggested based on the realization that in Dubai, the best quality data for the KPIs were reported by the entities that had direct control and management over the aspect evaluated.

  ➢ Before the KPI assessment process takes place, aspiring smart cities could develop and implement a KPI analysis and quality control mechanism. This will facilitate the KPI verification process and will allow entities to establish instruments to improve KPI quality and report on it accordingly.

▪ Cities commencing their smart city journeys, can use ITU's smart sustainable cities KPIs as a reference and guideline to initiate the process of determining strategic smart city goals to improve the sustainability and smartness of the city. Dubai's integrated approach to evolve into a smart city, along with a solid set of smart sustainable City KPIs, can facilitate the definition of global smart sustainable city goals and indicators for cities. This can be achieved through the sustained provision of guidance, methodological training, better information exchange, and the utilization of ICT tools.

▪ Emerging smart cities could consider defining specific policies and programs for the continued professionalization of smart sustainable city experts around the globe. This could be done through the creation of technical working groups, the development of specialized alliances with universities, the elaboration of specialized academic and entrepreneurship programs, etc. These activities will instil innovation and further ensure the expansion of smart sustainable cities initiatives within the cities as well as worldwide.

▪ Cities participating the ITU smart city pilot projects are advised to complete the two year pilot project to assess and compare the achievements and improvements of KPI collection process and use, between the first and second year of implementation.

▪ Ambitious urban stakeholders may also consider implementing the set of revised KPIs for SSC which are based on Recommendation ITU-T Y.4903/L.1603 "Key performance

indicators for smart sustainable cities to assess the achievement of sustainable development goals" and are being developed within the U4SSC Initiative. This will ensure that their cities move on the path to achieving the sustainable development goals while also fulfilling their smart city aspirations.

- Cities participating in the ITU smart city pilot projects, are encouraged to align their smart city vision with their national goals on smartness and sustainability. Existing smart city targets can also be expanded on to account for the sustainable development goals, COP21 targets and international agreements.

4.5. ITU's future role in the promotion of smart sustainable cities worldwide

As is evident from this case study, ITU has closely assisted Dubai in this pilot project. To boost ITU's capacities in conducting future pilot projects, this section provides suggestions for ITU and its partners to improve future processes related to smart city projects and stabilize ITU's learning curve.

As the curtains fall on the first year of ITU's and Dubai's pilot project, ITU and its partners encouraged to take the following actions:

- ITU is encouraged to gather feedback and conclusions of the first year of the Dubai pilot project so they can be included in the revised KPIs which are being developed within U4SSC.

- The Advisory Board for Smart Sustainable Cities should take note of the findings of the Dubai pilot project on the applicability of the KPIs contained in the Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. This feedback should contribute to the development of new standards, which seek alignment with other existing international standards especially those related to smart cities, city transportation, resource management, including water and electricity among others.

- U4SSC should share the findings and best practices of the Dubai pilot project with other cities in the process of testing the KPIs included in Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. This will help facilitate the assessment and verification processes of upcoming smart cities.

- Advisory Board for Smart Sustainable Cities should consider the Dubai experience as one of the major sources of information to improve the quality of the KPIs in terms of their definition, formulation, and measurement.

- ITU-T SG20 is invited to work further with national jurisdictions to reconcile fundamental concepts as many of the basic concepts used by the indicators may be defined differently in different cities. Accordingly, ITU may collaborate with national and local stakeholders to operationalize these concepts in a meaningful way so as to maximize the validity of the measures that are being used.

- Advisory Board for Smart Sustainable Cities should continue to review in detail the meaning and content of the KPIs dimensions and adapt them to the concerned cities'

strategic pillars in order to improve the overall understanding of the KPIs in relation to a given city's smart city dimensions.

5. Conclusions

The transition to a smart sustainable city is an on-going and evolving process. As the sun sets on the first year of the Dubai pilot project, this case study presents the path for the future based on the infinite smart city wisdom gained by ITU and Dubai during the first leg of their limitless "smart" journey.

This case study exclusively examines Dubai's journey to becoming a smarter and more sustainable city. It also provides an overview of the main steps adopted by Dubai in this endeavour.

In May 2015, ITU and Dubai signed a cooperation agreement to test the KPIs for smart sustainable cities contained in Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602. These Recommendations provide a framework to assess the use of ICTs in smart sustainable cities and to evaluate the impact of this use on a city's smartness and sustainability.

The first year of the ITU-Dubai pilot project took place from July 2015 to December 2015. Dubai, as the first city to test the KPIs, has set the path for other cities to understand the importance of assessment frameworks in advancing smart sustainable city initiatives. From Dubai's experience, the following conclusions have been gathered:

- During its development, cities need to improve the definition of certain KPIs to facilitate the collection process on a city level. Furthermore, during the collection process, cities may need further guidance and a clear methodological framework to facilitate analysis and data collection procedures. ITU should work in this direction and provide the mechanisms to standardize KPIs collection methodologies.

- ITU should apply the lessons learned from the pilot project undertaken by Dubai to the KPI assessment and verification processes carried out in other cities which are participating in ITU's pilot project. The results from this case study are still a work in progress and hence aspiring smart cities are advised to not to directly use the results from the first year of the pilot project in Dubai as the baseline or for comparability at this stage. Interested cities may follow the work conducted during the upcoming second year of the Dubai pilot project and could derive benefits from the best practices and opportunities for improvements as given in this case study.

- ITU may consider developing a generic "applicability checklist" before commencing the data collection process to determine how many KPIs will be considered applicable to a given city.

- ITU could also establish a score card for the cities participating the pilot project. Only the city administrators will be notified of the scores for their city. These scores will help cities ascertain their smart city progress between verification periods.

- The assessment carried out in Dubai, as the first city across the globe to use the KPIs contained in Recommendations ITU-T Y.4901/L.1601 and ITU-T Y.4902/L.1602, has set the basis for a roadmap of standardization activities and processes to support transitions to smart sustainable cities worldwide. Standardization efforts should be developed, taking into account the results of this pilot project. U4SSC has the possibility to utilize the results of the assessment and verification processes for future standardization efforts, wherein the participation of Dubai will be critical for success.

- ITU and UNECE have been working on the development of a framework for smart sustainable cities worldwide. The UN Initiative, United for Smart Sustainable Cities (U4SSC) is developing a Global Smart Sustainable City Index that will take into consideration the results and recommendations resulting from the pilot project in Dubai.

- Smart sustainable cities KPIs contained in Recommendations ITU-T Y4901/L.1601 and ITU-T Y4902/L.1602, have been tested in Dubai and have been reported based on the existence of mature ICT services available in the city. Thus, the pilot project has demonstrated that Dubai believes in the power of ICTs to transform its city infrastructure and optimize city services, in a broader context. Having incorporated ICTs to a wide-array of urban services, for the second stage of the pilot project, Dubai can focus on reaping the benefits of ICTs and directing their efforts towards the delivery of sustainability benefits to the city. Given the commendable steps already taken by Dubai in their smart city venture and the anticipated bolstering of their sustainability activities (based on the first year of the pilot project), it is expected that following the completion of this two year pilot project, Dubai will be able to crown themselves as a "smart sustainable city", one of the first of their kind.

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Annex 1

KPIs List

This Annex presents a detailed list of the KPIs verified during the first year of the pilot project for the Emirate of Dubai. Each KPI is described with its classification, type and unit of measurement. The analysis provided for these KPIs may change without prior notification as the pilot project progresses and the KPIs are updated.

1. Information and Communications Technologies (ICTs) Dimension

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D1.1 Networks and Access	I	111	Availability of computers or similar devices	Proportion of households with at least one computer or similar device (tablet, PCs, etc.)	These indicators are consistent with the ITU World telecommunication indicators. In Dubai, these indicators show high level of use and access to ICTs. This means that the smart city applications can be easily deployed and can be used by large sections of the population. Ongoing data collection in Dubai will provide the basis for analysis of maturity in the use of ICTs by citizens in a smart city context.
D1.1 Networks and Access	I	112	Availability of Internet access in households	Proportion of households with Internet access for any household member via a fixed or mobile network at any given time	
D1.1 Networks and Access	I	113	Availability of fixed broadband subscriptions	Fixed (wired) broadband subscriptions per 100 inhabitants.	
D1.1 Networks and Access	A	112	International Internet bandwidth	International Internet bandwidth (bit/s) per Internet user (*)	

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D1.1 Networks and access	A	117	Availability of Wi-Fi in public areas	Number of (public) Wi-Fi hotspots at certain points in the city.	These KPIs indicate the presence of Wi-Fi access in public areas and the availability of mobile-payment platforms. However these KPIs can reflect access to these services on a city level but not the level of coverage of the service. Further evaluation of KPIs (in Dubai) over a period of several years will give insights on its support to smart city projects development.
D1.2 Services and information platforms	A	121	Availability of electronic and mobile payment platforms	Existence of public electronic and mobile payment platforms to facilitate access to city services for city inhabitants.	
D1.3 Information security and privacy	I	131	Information security of public services and systems	Proportion of people who were victims of incidents, due to illegal system access, unauthorized data storage or transmission, unauthorized hardware and software modifications, which lead to information disclosure or financial loss.	This indicator determines Dubai's diligence in the control and management of information security in public services and systems.
D1.4 Electromagnetic fields	I	141	Compliance with WHO endorsed exposure guidelines	Application of WHO endorsed exposure guidelines for ICT installations in the city. NOTE – WHO endorsed exposure guidelines are referred to in (ITUT TR EMF Cons)	This indicator reflects Dubai's application of EMF Standards for installation in cities.

2. Environment Dimension

Sub-dimension	I: Core A: Additional	KPI Nº	Indicator	KPI definition	KPI Analysis
D2.1 Air quality	I	211	Application of ICT based monitoring system for particles and toxic substances (air quality)	Proportion of city area covered by outdoor ICT based monitoring system for particles and toxic substances (air quality) monitoring	This KPI shows the use of ICTs for air quality monitoring in Dubai. In Dubai, this KPI reflects that the existent monitoring systems have ICT systems to support city measurements of air quality. This KPI has to be analysed over a period of time, together with the air pollution intensity KPI, in order to understand the impact of the use of ICTs in air quality management.
D2.1 Air quality	I	212	Air pollution intensity	Level of particles and toxic substances is based on five aspects: ground-level ozone, particulate matter, carbon monoxide, sulphur dioxide, and nitrogen dioxide, measured by the Air Quality Index (AQI)	This KPI reflects the importance of air quality management in an international city like Dubai.

Sub-dimension	I: Core A: Additional	KPI Nº	Indicator	KPI definition	KPI Analysis
D2.2 CO2 emissions	A	221	GHG emissions per sector / per capita.	GHG emissions per sector including industrial (manufacturing, construction), commercial, household, transport, and waste disposal etc.	The analysis of the total emissions in Dubai per sector reflects that the major contributor to the city emissions is the Utilities Sector followed by the Manufacturing and transport and Waste Management. Tracking these KPIs allow planning and definition of integrated policies to reduce these emissions on a city level, and promote traceability of CO_2 and energy reduction targets established by the city for 2021.
D2.2 CO2 emissions	I	221	GHG emissions	Amount of GHG emissions per capita. tonnes CO2 eq/inh	Per capita emissions in Dubai were determined to be relatively high when compared with other cities as dense and populated as Dubai (as shown in the CDP Analysis of impacts of city population and density on GHG emissions per capita, reference).[4]
D2.3 Energy	A	231	Electricity use for street lighting	Electricity used for street lighting per km.	This KPI establishes the baseline to analyse the impact of future projects to reduce the electricity consumption, specially ICT based solutions such as smart public lighting services.

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D2.3 Energy	I	232	Energy saving in households	Energy saving in households compared to a baseline. NOTE – The baseline may be either a previous measurement or a reference value.	This KPI establishes the baseline for comparison in the following reporting period. This evaluation will require the implementation of energy efficiency projects using ICTs, especially in households.

The value reported for 2014 will become the baseline year for Dubai 4. |
| D2.5 Water, soil and noise | I | 251 | Application of city water monitoring through ICT | Proportion of the city water resources (rivers, lakes etc.) monitored by ICT with respect to availability | This KPI shows the use of ICTs for water quality monitoring in Dubai, reflecting that the existent monitoring systems have ICT systems to support city measurements. These KPIs have to be analysed over a period of time, together with water quality KPIs in order to understand the impact of the use of ICTs in water management. As such, both KPIs show that Dubai is working towards the integration of ICTs in water management, considering the importance of this resource in cities. |
| | I | 253 | Quality of city water resources | Quality of water resources (rivers, lakes etc.).

NOTE – Pollution of water resources includes (but is not limited to) acidity, organic, floatables, alga, chemical substances and bacteria, etc. | |

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D2.5 Water, soil and noise	I	254	Recycling of waste	Proportion of waste recycled compared to total collected waste.	This KPI indicates recycling rates of solid waste in the city. Internationally, values less than 25% recycling capacity are considered low. Cities in developing countries recycle more than 30% of their total collected waste and expect to raise their recycling rates to 65% by the year 2030. This KPI should be evaluated together with waste collection rates.[5]
D2.5 Water, soil and noise	I	257	Green areas surface	Proportion of municipal territory allocated as publicly accessible green areas.	This KPI shows the proportion of green areas in Dubai. It is important to evaluate this KPI together with the green area per capita value (m^2/inh) or hectares / 100 000inh. Internationally, values higher than 9m^2/inh or more than 50 hectares/100000 inh is considered acceptable for a city.[6]

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[5] EU waste management targets. http://ec.europa.eu/environment/waste/target_review.htm

[6] http://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Paper-11_Public-Space-2.0.compressed.pdf

3. Economy and Productivity Dimension

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D3.2 Employment	i	321	Service industry employment	Proportion of employees working in service industry in the city compared with the total employed workforce.	This KPI shows that the service industry in Dubai is relevant. The analysis of this KPI should be developed in an integrated context with other industries, especially the ICT sector (KPI I392) and technology based-employment. This will show a relationship with smart city services development. Note – Service industry companies are involved in retail, transport, distribution, food services, as well as other service-dominated businesses. This is also called service sector or tertiary sector of industry.
D3.3 Inflation	A	331	Inflation rate	A city's inflation rate is based on a projection of its Consumer Price Index, which measures the rise in prices of goods and services. (*) NOTE – National inflation data may be used.	This indicator is an economic KPI, corresponding to the national UAE value, whose impact in smart cities development should be further evaluated.

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D3.4 Trade	I	341	Application of public e-commerce transactions	Number of e-commerce transactions per 100 inhabitants through electronic and mobile payment.	This KPI indicates an important penetration of electronic and mobile payments platforms in the public services only. In Dubai this KPI reflects access to these services on a city level. However, further exploration of smart city service relationships and the impact of private e-transactions should also be done. Note: E-commerce can be defined generally as the sale or purchase of goods or services, whether between businesses, households, individuals or private organizations, through electronic transactions conducted via the internet or other computer-mediated (online communication) networks.
D3.8 Innovation	I	383	ICT related patents	Number of ICT related patents granted per 100,000 inhabitants	This KPI shows that ICT related patents in Dubai are starting to be of relevance. Globally, this KPI is usually evaluated on a country level and segregated by type of ICT related sub-sector. Growing economies report higher number of patents worldwide.[7]

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[7] OECD Digital Economy Outlook 2015 - © OECD 2015 http://www.oecd.org/sti/ieconomy/oecdkeyictindicators.htm
Chapter 2. The foundations of the digital economy. Figure 2.15 Specialisation in ICT-related patents, 2000-02 and 2010-12.

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D3.9 Knowledge economy	I	392	Employees belonging to ICT sector	Proportion of employees involved with ICT	This KPI shows an important aspect, which is the ICT based-employment and its potential relationship with smart city services development.
D3.9 Knowledge economy					This KPI is representative (in Dubai) if compared with developing country values. The average value in OECD countries is 2,71%.[8] Note: ICT Sector and subsectors include among others and as of OECD classification: ICT service providers (telecommunications, software); ICT manufacturers, and ICT trade companies.
	I	393	Public Companies providing e-services	Proportion of public companies which provide network based services (including e-commerce, e-learning, e-entertainment, cloud computing etc.).	This KPI indicates an important level of access to e-government services across the city. Further evaluation of this KPI over a period of several years will give insights on its support to smart city projects development.

4. Quality of Life Dimension (Smart Living)

Sub-dimension	I: Core A: Additional	KPI Nº	Indicator	KPI definition	KPI Analysis
D4.2 Health	I	422	Use of electronic medical records	Proportion of city inhabitants who have electronic medical records in the public health system.	This KPI indicates an important penetration of use of medical records in Dubai`s public health system. This KPI should be evaluated in the public/private context, based on the use of ICTs to support health management systems and the deployment of e-health services over several years.
	I	425	Healthy life years (HLY)	Number of remaining years that a person of a certain age is expected to live without disability.	This KPI designates Dubai as a city with average of life expectancy years at least 5% below the values in developed countries (located in Europe). Further evaluation is needed with the HLY indicator.
D4.3 Safety/security public place	I	431	Adoption of ICT for disaster management	Adoption of an ICT based disaster management systems including disaster preparedness, prevention, mitigation, and response as applicable to the city.	This qualitative KPIs indicates the vision of Dubai on the inclusion of disaster risk management. Evolution of the KPI will require annual evaluation and quantitative indicators that evaluate the impact of the use of ICTs for disaster management.

Sub-dimension	I: Core A: Additional	KPI Nº	Indicator	KPI definition	KPI Analysis
D4.3 Safety/security public place	I	432	Availability of ICT based safety systems	Availability of ICT based systems that increase the perceived safety. NOTE – This may include solutions such as video surveillance system, online information published by the police, online support for protection of women and children, community incident mapping etc.	This qualitative KPI indicates the availability of ICT based management systems to increase safety. Evolution of the KPI will require annual evaluation and quantitative indicators.
	I	433	Disaster and emergencies alert accuracy	Proportion of disasters and emergency events with timely alerts. NOTE – Disasters may be natural or man-made. Emergencies concern incidents like kidnapping and missing people, etc.	At this stage this KPI was reviewed only with reference to the systems in place, to provide timely alerts. This KPI has not been reported as a proportion at this time. Evolution of the KPI will require a further review of the definition, annual evaluation and quantitative indicators.

5. Equity and Social Inclusion

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D5.3 Openness and public participation[9]	A	531	Availability of cultural resources online	Proportion of cultural institutions and events in the city for which online participation is offered.	Openness and public participation KPIs clearly reflect the availability of services that promote public participation and city services use in Dubai.

The KPI reported by Dubai may not reflect the impact of the use of ICTs in an effective interaction among the city government and the citizens. These KPIs should be evaluated over a timeframe of several years.

These KPIs on openness and public participation will be revised during ITU-T standardization efforts. The required improvements include: better and clearer definitions and further details on data collection |
	I	531	Availability of online city information and feedback mechanisms	Proportion of city information available online and existence of ICT systems for easy access and anonymous feedback mechanism that enable cities to improve their governance.	
	I	532	Online civic engagement	Proportion of city inhabitants using public online information and proportion of city inhabitants using ICT based feedback mechanism.	
	I	534	Existence of strategies, rules and regulations to enable ICT literacy among inhabitants	Existence of strategies, regulations, voluntary work or interest organizations to enhance ICT literacy among all city inhabitants.	
	I	535	Use of online city services	Proportion of city inhabitants using online public services and facilities (e.g., choice of schools, booking of public sports facilities, library services, etc.).	

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9   Correspondent to Dubai Smart People Dimension evaluation.

Sub-dimension	I: Core / A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D5.4 Governance	I	541	Provision of online systems for administering public services and facilities	Proportion of public services and facilities (e.g., choice of schools, booking of public sports facilities, library services, etc.) that could be administered online.	This KPI shows an important level of penetration of online systems for citizens to access to public services and facilities. Future evaluation on the use of the services is needed
	I	542	Application of services to support persons with specific needs	Proportion of public facilities and buildings that provide ICT based services and information to support persons with specific needs, and proportion of online public information customized for these persons.	This KPI may not be representative of the whole value chain for provision of services for smart cities for people with specific needs. It only reflects the web-based services. Further evaluation will be needed in future collection periods.

6. Physical Infrastructure Dimension

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D6.1 Infrastructure /connection to services – piped water	A	612	Quality of piped water	Quality of water as supplied to end users. (i.e. percentage of tests that passed water quality standards)	Water related KPIs show that Dubai is using ICT-based systems to support the quality management and control of water provision. Further evaluation should be conducted on the impact of the use of ICTs in supporting water quality management, based on targets. Water quality takes on a broad definition with respect to the ''physical, chemical, and biological characteristics of water necessary to sustain desired water uses". Water quality standards are local specific, though there are minimum international guidelines for water quality for drinking water. For example, the WHO guidelines: http://apps.who.int/iris/bitstream /10665/44584/1/9789241548151 _eng.pdf
	I	611	Water supply system management using ICT	Proportion of the water supply systems under automatic monitoring using ICT so as to ensure water quality.	
	I	612	City fresh water sources monitored using ICT	Proportion of the city fresh water (or not) sources monitored using ICT with respect to availability.	

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
	I	613	Availability of smart water meters	Proportion of the water consumers (including households, companies, etc.) with ICT based water meters.	This KPI shows the Dubai's commitment to install smart water meters in the city. This KPI should be evaluated over the years, and should be linked to city targets in this matter.
	I	614	Leakage in water supply system	Proportion of water leakage in the water supply system.	This KPI is linked to control of the water supply provision in the city with the use of ICTs. This KPI shows the efforts made by Dubai to include ICTs in their water supply system.
D6.2 Infrastructure/ connection to services - sewage	I	621	Sewage system management using ICT	Proportion of the sewage system monitored using ICT	This KPI shows an important coverage of the network of sewage systems using ICTs. It should be evaluated with the KPI related to sewage system coverage (in order to evaluate the impact of ICTs in the efficiency of the sewage collection network.

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D6.2 Infrastructure/ connection to services - sewage	I	622	Drainage system management using ICT	Proportion of the drainage systems monitored in real-time using ICT.	This KPI shows the efforts of Dubai in including ICT-based monitoring in drainage systems. This KPI must be evaluated over a period of time to assess the evolution of ICT use for these systems and assess its efficiency and effectiveness.
	I	623	Sewage system coverage	Proportion of households connected to the sewage system.	This KPI shows an important coverage of sewage system in the city. The percentage of households with home connection to the sewer system is an indicator of city health, hygiene, and quality of life. Internationally cities with coverage values of more than 75% are recognized as effective in the provision of this service.[10]

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[10] IDB. Indicators of the Emerging and Sustainable Cities Initiative. http://issuu.com/ciudadesemergentesysostenibles/docs/esci_indicators_en

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D6.3 Infrastructure/ connection to services – electricity	I	631	Availability of smart electricity meters	Proportion of the electricity consumers (including households, companies, etc.) with ICT based electricity meters.	This KPI shows the Dubai's commitment to install smart electricity meters in the city and its integration to future smart grids. This KPI should be evaluated over the years, and should be linked to city targets in this matter.
	I	632	I6.3.2 Reliability of electricity supply system	Annual average of daily number of hours of continuous electricity supply per household (in hours/day).	This KPI shows the efficiency of the electricity supply system in Dubai, whose values, in reference to international benchmarking perform well.[8] Dubai should evaluate the evolution of the different indexes (SAIFI, SAIDI, CAIDI)[11] over time and relate them with the progressive inclusion of ICT technologies to support the management and efficiency of the electricity system.

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[11] SAIDI: System Average Interruption Frequency Index, provides frequency of sustained interruptions per customer over a defined time. Its equation is: Total number of customer interruptions/ Total number of customers served.

SAIFI: System Average Interruption Duration Index, provides information on the average time that customers are interrupted. Its equation is: Sum of Customer Interruption duration / Total number of customers served.

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D6.7 Infrastructure /connection to services – transport	I	671	Use of public transport	Proportion of travellers typically utilizing public transport (including taxi) compared to overall city population.	This KPI shows that a significant proportion of the population in Dubai uses public transport. This value should be assessed in relationship with other transportation modes, including private cars. This relationship is important as smart sustainable cities are looking for increased use of public transport with the support of ICTs.
	I	672	Road traffic efficiency	Measured by the average travel speed for all private motorized vehicles and public transit vehicles that use roads (e.g., excluding trains or trolleys), across all locally defined "thoroughfares" during the peak hours (typically, morning and evening).	This KPI value corresponds to the Travel Time Index (TTI) of Dubai; and it is aligned with Dubai`s target on transport efficiency. Dubai has recommended the use of this KPI, which represents the ratio of the peak-period travel time as compared to the free-flow travel time. This measure is computed for the AM peak period (6:00 a.m. to 9:00 a.m.) and PM peak period (4:00 p.m. to 7:00 p.m.) on weekdays. Averages across urban areas, road sections, and time periods are weighted by vehicle miles travelled.

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D6.8 Infrastructure/ connection to services – road	A	682	Availability of online bicycle/car sharing system	Proportion of city area covered by an online bicycle/car sharing system	This KPI shows the availability of car sharing and bike sharing systems in the Dubai. However, they do not indicate the penetration and use of the service or rate of use by city inhabitants. Further evaluation with other KPIs per type of sharing system, applications used, level of occupancy, etc., should be carried out.
	I	681	Availability of traffic monitoring using ICT	Proportion of streets with traffic monitoring using ICT (e.g., using sensors to produce traffic volume maps etc.).	These KPIs indicate an intensive level of use of ICTs in the transport sector of Dubai, demonstrating a high level of understanding of the importance of the use of ICTs to increase transport sustainability. Further evaluation of KPIs in the transport sector should be linked to its sustainability impacts: GHG emissions, energy consumption, accidents, fatalities, etc. An analysis of indicators related to change of the modal share in the city would be complementary to this KPI analysis.
	I	682	Availability of parking using ICT	Proportion of public paid parking lots and street parking spaces with ICT based e payment systems	
	I	683	Availability of real-time traffic information	Proportion of public transport stops and stations with real-time traffic information available (via electronic bus bulletin boards, smartphone apps etc.)	

Sub-dimension	I: Core A: Additional	KPI N°	Indicator	KPI definition	KPI Analysis
D6.11 Building	I	6112	Integrated management in public buildings	Proportion of public buildings using integrated ICT systems to automate building management and create flexible, effective, comfortable and secure environment.	This KPI shows the importance of the use of ICTs in supporting building efficiency in the public sector. Further evaluation of the integration of ICTs for energy management in buildings should be conducted together with energy consumption and GHG emissions KPIs. This KPIs should contribute to Dubai`s process of building efficiency in the whole city.

N.B: This Annex includes the preliminary list of KPIs which were tested in Dubai. The revised versions of the KPIs based on Dubai's inputs may or may not have the same definition, scope or validity. Hence, the current KPIs may not be explicitly comparable to the revised list of KPIs, which will be used in other cities and in Dubai itself during the second year of the pilot project. Nevertheless, the KPI analyses and other findings from Dubai will serve endless in setting the baselines/thresholds for the future and in deducing improvements. The data for the KPIs have been collected and their actual values have been validated by ITU through a rigorous verification and validation process facilitated by Smart Dubai, in collaboration with various entities in Dubai. Please note that the values of the verification process have not been provided in Annex 1 for confidentiality reasons. However, readers can avail of Dubai's experience based on the information and deliberations provided in the KPI Analysis column.

2019

2018

2017

2016