International Telecommunication Union

ITU-T Y.4900/L.1600

(06/2016)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

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Internet of things and smart cities and communities – Evaluation and assessment

Overview of key performance indicators in smart sustainable cities

Recommendation ITU-T Y.4900/L.1600

International Telecommunication Union

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Recommendation ITU-T Y.4900/L.1600

Overview of key performance indicators in smart sustainable cities

Summary

Recommendation ITU-T Y.4900/L.1600 gives a general guidance to cities and provides an overview of key performance indicators (KPIs) in the context of smart sustainable cities (SSCs).

This Recommendation is one of series of the Recommendations and Supplements that define KPIs. The series of KPI definitions documents also include:

- Recommendation ITU-T Y.4901/L.1601 on key performance indicators (KPIs) related to the use of information and communication technology (ICT) in smart sustainable cities. This Recommendation lists the KPIs focusing on ICT use in smart sustainable cities (SSCs).
- Recommendation ITU-T Y.4902/L.1602 on key performance indicators (KPIs) related to the sustainability impacts of information and communication technology (ICT) in smart sustainable cities. This Recommendation lists the KPIs used for ICT impact on sustainability.
- Supplement ITU-T Y-Suppl. 39 on key performance indicators (KPIs) for smart sustainable cities. This document provides information regarding KPIs and evaluation index systems of smart cities, KPIs of sustainable cities, etc.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4900/L.1600	2016-06-06	5	11.1002/1000/12627

Keywords

Cities, ICT, information communication technology, key performance indicator, KPI, metrics and evaluation, smart sustainable cities, SSC, sustainability impacts.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Overview of key performance indicators in smart sustainable cities

1 Scope

This Recommendation outlines the key performance indicators (KPIs) in the context of smart sustainable cities (SSC). Evaluating these indicators can help cities as well as their stakeholders understand to what extent they may be perceived as smart sustainable cities (SSCs).

The sustainability of a smart city is based on four main aspects:

– Economic: The ability to generate income and employment for the livelihood of the inhabitants.

– Social: The ability to ensure that the welfare (safety, health, education) of the citizens can be equally delivered despite differences in class, race or gender.

– Environmental: The ability to protect future quality and reproducibility of natural resources.

– Governance: The ability to maintain social conditions of stability, democracy, participation and justice.

This Recommendation can be utilized by:

– Cities and municipal administrations, including the SSC-relevant policy-making organizations, and government sectors, enabling them to develop strategies and understand the progress related to the use of ICT for making cities smarter and more sustainable.

– City residents and non-profit citizen organizations, enabling them to understand the development and progress of SSCs with respect to the impact of ICTs.

– Development and operation organizations of SSC, including planning units, SSC-related producers and service providers, operation and maintenance organizations, helping them to fulfil the tasks of sharing information related to the use of ICT and its impact on the sustainability of cities.

– Third party agencies and academia, supporting them in the selection of relevant KPIs for assessing the contribution from ICTs in the development of SSCs.

The intention of KPIs is to publish the criteria to evaluate ICT´s contributions in making cities smarter and more sustainable, and to provide the cities with the means for self-assessments. It is desirable that each city can quantify continuously an achievement degree according to their goal following KPIs.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.4901] Recommendation ITU-T Y.4901/L.1601 (2016), *Key performance indicators related to the use of information and communication technology in smart sustainable cities.*

[ITU-T Y.4902]	Recommendation ITU-T Y.4902/L.1602 (2016), *Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities.*
[ITU-T Y-Sup.39]	ITU-T Y-series Recommendations – Supplement 39 (2015), *ITU-T Y.4900 Series – Key performance indicators definitions for smart sustainable cities.*
[ISO 37120]	ISO 37120:2014, *Sustainable development of communities – Indicators for city services and quality of life.*

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 city: A urban geographical area with one (or several) local government and planning authorities.

3.2.2 smart sustainable city: 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.

NOTE – City competitiveness refers to policies, institutions, strategies and processes that determine the city's sustainable productivity.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

GHG	Greenhouse Gas
ICT	Information and Communication Technology
KPI	Key Performance Indicator
OSI	Open Systems Interconnection
SSC	Smart Sustainable City
UN-Habitat	United Nations Human Settlements Programme

5 Overview of key performance indicators (KPIs) in a city context

The series of KPI for SSC Recommendations and Supplements also include:

– Recommendation [ITU-T Y.4901] on key performance indicators (KPIs) related to the use of information and communication technology (ICT) in smart sustainable cities. This Recommendation lists the KPIs focusing on ICT use in SSCs.

– Recommendation [ITU-T Y.4902] on key performance indicators (KPIs) related to the sustainability impacts of information and communication technology (ICT) in smart sustainable cities. This Recommendation lists the KPIs used for ICT impact on sustainability.

– Supplement [ITU-T Y-Sup. 39] on key performance indicators (KPIs) for smart sustainable cities. This document provides information regarding KPIs and evaluation index systems of smart cities, KPIs of sustainable cities, etc.

6 Key performance indicators

6.1 Dimensions of KPIs

This Recommendation takes into consideration the definition of SSC, the City Prosperity Index of UN-Habitat [b-UN-Habitat report], and [ISO 37120]. The proposed set of KPIs focuses specifically on a set of ICT-related indicators for smart sustainable cities and does not cover all KPIs of cities contained in [ISO 37120].

The dimensions of KPIs can be categorized as shown in Figure 1:

– Information and communication technology[1]
– Environmental sustainability
– Productivity
– Quality of life
– Equity and social inclusion
– Physical infrastructure.

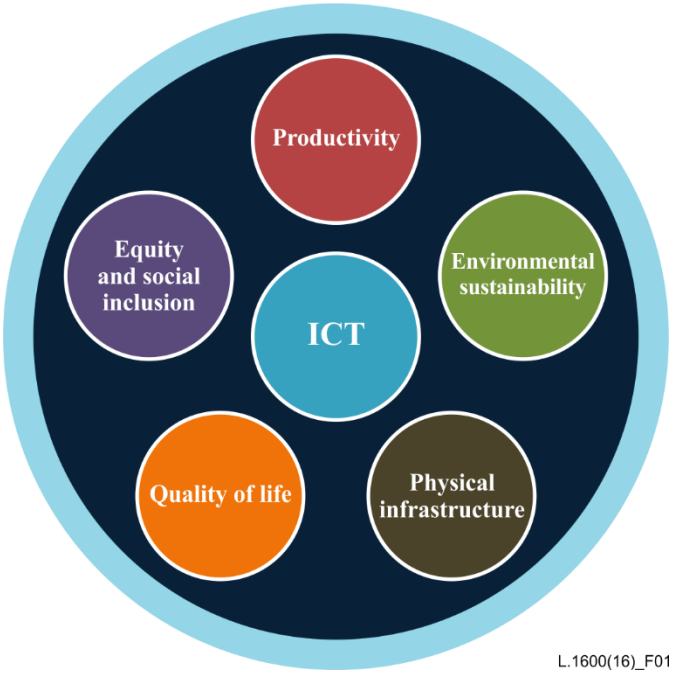

Figure 1 – Dimensions of KPIs for SSCs

6.2 Sub-dimensions of KPIs

The sub-dimensions for each dimension are recorded in Table 1 and explained in the succeeding subsections.

In Table 1 each dimension is identified by the letter Dx. The sub-dimensions are then classified by the label Dx.y where x maps to dimension and y maps to sub-dimension.

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[1] In the UN-Habitat prosperity index, ICT forms part of the general 'Infrastructure' category. ICT is defined as a separate category to highlight the focus of ITU.

Table 1 – Sub-dimension of KPIs

Dimension #	Dimension	Sub-dimension #	Sub-dimension
D1	Information and communication technology	D1.1	Network and access
		D1.2	Services and information platforms
		D1.3	Information security and privacy
		D1.4	Electromagnetic field
D2	Environmental sustainability	D2.1	Air quality
		D2.2	CO2 emissions
		D2.3	Energy
		D2.4	Indoor pollution
		D2.5	Water , soil and noise
D3	Productivity	D3.1	Capital investment
		D3.2	Employment
		D3.3	Inflation
		D3.4	Trade
		D3.5	Savings
		D3.6	Export/import
		D3.7	Household income/consumption
		D3.8	Innovation
		D3.9	Knowledge economy
D4	Quality of life	D4.1	Education
		D4.2	Health
		D4.3	Safety/security public place
		D4.4	Convenience and comfort
D5	Equity and social inclusion	D5.1	Inequity of income/consumption (Gini coefficient)
		D5.2	Social and gender inequity of access to services and infrastructure
		D5.3	Openness and public participation
		D5.4	Governance
D6	Physical infrastructure	D6.1	Infrastructure/connection to services – piped water
		D6.2	Infrastructure/connection to services – sewage
		D6.3	Infrastructure/connection to services – electricity
		D6.4	Infrastructure/connection to services – waste management
		D6.5	Connection to services – knowledge infrastructure
		D6.6	Infrastructure/connection to services – health infrastructure

Table 1 – Sub-dimension of KPIs

Dimension #	Dimension	Sub-dimension #	Sub-dimension
		D6.7	Infrastructure/connection to services – transport
		D6.8	Infrastructure/connection to services – road infrastructure
		D6.9	Housing – building materials
		D6.10	Housing – living space
		D6.11	Building

6.3 Description of dimensions and sub-dimensions of KPIs

6.3.1 D1 ICT

D1 concentrates on ICT infrastructure, which is the basis for other ICT solutions and smart sustainable promotions. The ICT infrastructure includes network and access (D1.1), services and information platforms (D1.2), information security and privacy (D1.3), and Electromagnetic field (D1.4).

D1.1 Network and access

Network and access refers to the network layer in the Open Systems Interconnection (OSI) model, especially backbone and access networks, including optical broadband, wireless broadband and broadcasting network.

D1.2 Services and information platforms

Services and information platforms refers to ICT services and equipment above the network layer, including software services and private handsets.

D1.3 Information security and privacy

Information security and privacy refers to the security parts including privacy protection.

D1.4 Electromagnetic field

Application of exposure guidelines, consistent planning approval process and information for public should be considered with respect to electromagnetic fields.

6.3.2 D2 Environmental sustainability

D2 examines the ICT usage and impact on key environmental areas. It is classified into five categories: air quality (D2.1), CO_2 emissions (D2.2), energy (D2.3), indoor pollution (D2.4), and water, soil and noise (D2.5).

D2.1 Air quality

This part looks into the quality of air which is an important area for consideration for many cities.

D2.2 CO_2 emissions

This parts looks into the CO_2-e emissions of the city where "-e" is "equivalent" and every other greenhouse gases (GHGs)are converted into CO_2.

D2.3 Energy

This part looks into the energy use of the city. Examples of energy used include, but are not limited to, electricity, steam energy, fossil fuels, etc.

D2.4 Indoor pollution

This part is about indoor environment.

D2.5 Water, soil and noise

This part collects elements such as water quality and noise.

6.3.3 D3 Productivity

The ICT impact on D3 Productivity would be evaluated in nine categories: capital investment (D3.1), formal/informal employment (D3.2), inflation (D3.3), trade (D3.4), savings (D3.5), export/import (D3.6), household income/consumption (D3.7), innovation (D3.8), and economic sustainability (D3.9). Economy is the driving engine of human society. Therefore, it is necessary to investigate whether or not SSC helps to prime the pump of the local economy. Meanwhile, innovation weighs increasingly in the economy. As high tech plays a pivotal role in SSC, it is valuable to find out the local competence of innovation.

D3.1 Capital investment

This part is about the capital investment when building SSC.

D3.2 Employment

This part is about the formal or informal employment in a city.

D3.3 Inflation

The indicator of inflation reflects the currency devaluation and price rise.

D3.4 Trade

This part is about the e-commerce transaction in SSC.

D3.5 Savings

This part is about the average household savings in SSC.

D3.6 Export/import

This part is about the export/import at the city level.

D3.7 Household income/consumption

This part is about the average household income/consumption in SSC.

D3.8 Innovation

This part assesses the city's ability of innovation through multiple perspectives. It would indicate whether it is an innovation city or innovative city. Innovative city refers to cities that can adjust to changes quickly and play as a regional lead.

D3.9 Knowledge economy

This part studies whether or not SSC is pumping the economy. Because of the fast growth and drastic changes of technology innovation as well as its close effect on the economy, industry, science and society, economic sustainability must face challenges from all these impacts.

6.3.4 D4 Quality of life

The ICT impact on D4 Quality of life in SSC would be sampled mainly in the following four sectors: education (D4.1), health (D4.2), safety/security public place (D4.3), convenience and comfort (D4.4). D4 will find out if ICT is helping people get a better life.

D4.1 Education

Education and training is critical to enhance human creativity and social quality. This section examines how ICT modernizes education and training.

D4.2 Health

Health care here refers specifically to medical services. Citizens are complaining more and more about limited medical resources and skewed supply and demand relationship. This part investigates how ICT contributes to solve this problem.

D4.3 Safety/security public places

Security and safety is the basic civil service guaranteed by governors since ancient times. Security concerns are mainly about man-made threats, specifically crimes and terrorism. Safety is about actions taken against natural disasters and accidents. ICT plays a vital role in these two areas.

D4.4 Convenience and comfort

This part is a complementary set of other objective research. It contains subjective feelings and impressions regarding various topics mentioned above as a result of questionnaires and interviews.

6.3.5 D5 Equity and social inclusion

The ICT impact on D5 Equity and social inclusion in SSC would be sampled in the following four sectors: inequity of income/consumption (D5.1), social and gender inequity of access to services and infrastructure (D5.2), openness and public participation (D5.3), and governance (D5.4). Governance and public service have a great influence on social development. It is obvious that modern governments must be open and highly efficient. Otherwise, frequent turbulence would jeopardize stability and development. D5 will find out if ICT is helping improve social harmony and administrative efficiency.

D5.1 Inequity of income/consumption

This part is about the inequity of income/consumption at the city level.

D5.2 Social and gender inequity of access to services and infrastructure

This part is about the social and gender inequity of access to services and infrastructure at the city level.

D5.3 Openness and public participation

Domestically, more and more people come to live in cities as a result of urbanization. Hence, it is important to help those citizens adapt easily to their new environment. In the background of globalization, every city is trying to attract tourists, talents and investment worldwide and there are multi-ethnic and multi-religion issues involved in this process. This part tries to discover how ICT could improve the openness of the city and its citizens.

Moreover, this part studies how ICT elevates people's willingness of participation. The citizenship spirit is reflected directly in the participation in public life.

A sustainable society should have a manageable wealth gap, and an open channel for citizens. It should be appealing, free and have a democratic environment for people to discuss and co-operate. This section checks if ICT is helping to increase social coherence and citizenship consciousness.

D5.4 Governance

This part investigates ICT applications in various administrative affairs and checks if they are helping to improve anti-corruption as well as government openness and efficiency.

6.3.6 D6 Physical infrastructure

The ICT impact on D6 Physical infrastructure would be evaluated in 11 categories: infrastructure/connection to services – piped water (D6.1), infrastructure/connection to services – sewage (D6.2), infrastructure/connection to services – electricity (D6.3), infrastructure/connection to services – waste management (D6.4), infrastructure/connection to services – knowledge infrastructure (D6.5), infrastructure/connection to services – health infrastructure (D6.6), infrastructure/connection to services – transport (D6.7), infrastructure/connection to services – road infrastructure (D6.8), housing – building materials (D6.9), housing – living space (D6.10), and building (D6.11). This part would focus on the improvement of the important municipal infrastructures.

D6.1 Infrastructure/connection to services – piped water

Municipal pipe networks, such as water, electricity, gas, and heating pipes, etc., stretch out to every corner of the city. There are various kinds of pipe networks which play an important role in the functioning of the city. These systems are colossal, complex and arduous to maintain. Moreover, they are not risk free, some even has a potentially fatal danger like the gas pipe network. Therefore, there is an urge for smart cities to upgrade their municipal pipe network maintenance with modern smart technologies.

D6.2 Infrastructure/connection to services – sewage

Sanitation is an important public service to prevent diseases from spreading. This part is mainly concerned with ICT's impact on sewage systems as well as garbage disposal and recycling.

D6.3 Infrastructure/connection to services – electricity

This part is about the infrastructure of electricity at the city level.

D6.4 Infrastructure/connection to services – waste management

This part is about the infrastructure of waste management at the city level.

D6.5 Connection to services – knowledge infrastructure

This part is about the knowledge infrastructure such as education, and culture at the city level.

D6.6 Infrastructure/connection to services – health infrastructure

This part is about the infrastructure of health care at the city level.

D6.7 Infrastructure/connection to services – transport

Transport is the hottest focus of civil services. Traffic jams have been a worldwide headache costing tremendous energy and expenses. This part investigates how ICT measures counter various negative transport effects.

D6.8 Infrastructure/connection to services – road infrastructure

This part is about the infrastructure such as roads, streets, lighting system at the city level.

D6.9 Housing – building materials

This part is about the building materials in SSC.

D6.10 Housing – living space

This part is about the average living space in SSC.

D6.11 Building

Most human activities take place inside buildings. Buildings are an everlasting symbol of urbanism and they grow hand in hand with the progress of urbanization. In this new era of smart sustainable cities, buildings are supposed to provide cosiness, convenience, resilience and energy efficiency beyond inhabitation and beauty. This part checks how ICT meets these goals.

Bibliography

[b-UN-Habitat report] UN-Habitat report (2013), *State of the World's cities 2012/2013 Prosperity of Cities.*

ITU-T L-SERIES RECOMMENDATIONS

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Printed in Switzerland
Geneva, 2016