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**Key performance indicators for smart
sustainable cities to assess the achievement of
sustainable development goals**

Recommendation ITU-T Y.4903/L.1603



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GLOBAL INFORMATION INFRASTRUCTURE

General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899

INTERNET PROTOCOL ASPECTS

General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999

NEXT GENERATION NETWORKS

Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999

FUTURE NETWORKS

Y.3000–Y.3499

CLOUD COMPUTING

Y.3500–Y.3999

INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES

General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.4903/L.1603

Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals

Summary

Recommendation ITU-T Y.4903/L.1603 gives general guidance to cities and provides key performance indicators (KPIs) for smart sustainable cities (SSC) to help cities achieve sustainable development goals (SDGs). This Recommendation has been jointly developed with UNECE and other UN agencies.

History

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Table of Contents

		Page
1	Scope.....	1
2	References.....	2
3	Definitions	2
3.1	Terms defined elsewhere	2
3.2	Terms defined in this Recommendation.....	2
4	Abbreviations and acronyms	3
5	Conventions	3
6	General principles for selecting key performance indicators (KPIs).....	3
7	Overview of key performance indicators	4
7.1	Definition of area, topic and type of KPIs.....	4
7.2	Description of areas and topics of KPIs	5
8	Key performance indicators of SSC	8
8.1	Economy.....	9
8.2	Environment	12
8.3	Society and culture	18
	Appendix I – Additional indicators.....	24
I.1	Economy.....	24
I.2	Environment	29
I.3	Society and culture	31
	Appendix II – Complete list of core and additional indicators	33
	Appendix III – KPI development in ITU-T	39
	Bibliography.....	41

Recommendation ITU-T Y.4903/L.1603

Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals

1 Scope

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

The sustainability of a smart city is based on five 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, etc.) 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.
- Cultural: The ability to promote cultural identity and adequacy, value and emotional well-being.

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 for making cities smarter and more sustainable.
- City residents and non-profit citizen organizations, enabling them to understand the development and progress of SSC.
- Development and operation organizations of SSC, including planning units, SSC-related producers and service providers and operation and maintenance organizations, helping them to fulfil the tasks of sharing information related to the use of information communication technologies (ICTs) and its impact on the sustainability of cities.
- Third party agencies and academia, supporting them in the selection of relevant KPIs for assessing the development of SSC.

The intention of identifying the KPIs is to establish the criteria to evaluate cities' performances and their progress towards becoming smarter and more sustainable and to provide the cities with the means for self-assessments. Cities are encouraged to periodically check their performances against the recommended indicators listed in this Recommendation in order to improve their performance.

This Recommendation lists the core indicators that have been selected as being applicable for all cities. The goals for moving towards increased smartness and sustainability differ between cities. Thus, based on their population growth, geographical locations, environmental conditions, demography, etc., cities may also select appropriate additional indicators among those listed in Appendix I.

This Recommendation focuses on general development of cities. Cities with particular interest in ICT development may refer to [ITU-T Y.4901] and [ITU-T Y.4902].

2 References

The following ITU-T Recommendations and other references contain provisions which, through references 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 ITU-T Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T Y.4900] Recommendation ITU-T Y.4900/L.1600 (2016), *Overview of key performance indicators in smart sustainable cities.*
- [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 K-Sup.4] ITU-T K-series Recommendations – Supplement 4 (2015), *Electromagnetic field consideration in smart sustainable cities.*
- [ITU-T Y-Sup.39] ITU-T Y-series Recommendations – Supplement 39 (2015), *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

This Recommendation uses the following terms defined elsewhere:

3.1.1 city [ITU-T Y.4900]: An urban geographical area with one (or several) local government and planning authorities.

3.1.2 ICT companies [ITU-T Y.4901]: Companies which provide products and/or services with respect to information and communication technologies.

3.1.3 knowledge economy [b-OECD KE]: Economies which are directly based on the production, distribution and use of knowledge and information.

3.1.4 smart sustainable city [ITU-T Y.4900]: 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.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AQI	Air Quality Index
BEV	Battery Electric Vehicle
BMI	Body Mass Index
BPL	Broadband-over-Power Line
CO ₂	Carbon dioxide
COP	Child Online Protection
EV	Electric Vehicle
FAO	Food and Agriculture Organisation
FCEV	Fuel Cell Electric Vehicle
GDP	Gross Domestic Product
GHG	Green House Gas
ICT	Information and Communication Technology
IP	Internet Protocol
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LAN	Local Area Network
PHEV	Plug-in Hybrid Electric Vehicle
PM ₁₀	Particulate Matter up to 10 micrometres in size
PM _{2.5}	Particulate Matter up to 2.5 micrometres in size
PPP	Purchasing Power Parity
QoL	Quality of Life
REEV	Range Extended Electric Vehicle
REX	Range Extender
SDG	Sustainable Development Goal
SMEs	Small and Medium-sized Enterprises
SSC	Smart Sustainable Cities
TCP	Transmission Control Protocol

5 Conventions

None.

6 General principles for selecting key performance indicators (KPIs)

The selection of KPIs is based on the following principles:

- Independent: The KPIs should be independent or almost-orthogonal i.e., overlap of the KPIs should be avoided as much as possible.

- Simple: The concept of each indicator should be simple and easy to understand. There has to be one widely-accepted definition of the KPI to make sure the different users interpret it in the same way. Also the calculation of the associated data should be intuitive and simple.
- Measurable: The KPIs should be defined in a way that the value can be measured and comparable scientifically between different phases of urban development, which means the KPIs should be comparable over time and space. The historic and current data should be either available or easy to collect.
- Achievable: The goal of KPIs should be achievable and the set of indicators should cover all aspects of SSC. It should also be possible to extend and amend the set of KPIs according to the actual stage of development.
- Relevant: The KPIs should give more insight into the performance of the city in obtaining its strategy. The indicators for evaluation should be aligned to the measured subject. The index system should reflect the level of general development for a particular aspect.
- Timely: It is important to express the value of the KPI in time. Every KPI has a meaning only if the time dimension in which it is realized is known. Hence, its realization and standardization has to be time phased. KPIs are also able to deal with emerging issues in SSC construction.

7 Overview of key performance indicators

7.1 Definition of area, topic and type of KPIs

This Recommendation is based on the series of Recommendations and Supplements on SSC KPIs [ITU-T Y.4900], [ITU-T Y.4901], [ITU-T Y.4902] and [ITU-T Y-Sup.39] and the UNECE smart cities indicators [b-UNECE indicators]. This Recommendation also takes into consideration the definition of SSC, the UN sustainable development goals [b-UN Resolution 288], the city prosperity index of UN-Habitat [b-UN-Habitat report] and ISO indicators for city services and quality of life [ISO 37120].

The set of KPIs has been structured according to three major aspects, namely areas, topics and types of indicator.

The areas represent the more generic dimensions which provide a framework for the set of indicators. They correspond to the three pillars of sustainability: economy, environment and society and culture.

The topic indicates a group of specific indicators which describe an area of potential development. Nineteen major topics are identified and each indicator is assigned to one specific topic. Some topics include specific sub-topics which can be considered as keywords that more thoroughly define the nature of the indicators. The topics are:

- Economy, including the following topics:
 - ICT infrastructure
 - Innovation
 - Employment
 - Trade (sub-topics: e-Commerce and export/import)
 - Productivity
 - Physical infrastructure (sub-topics: water supply, electricity, health infrastructure, transport, road infrastructure, buildings and urban planning and public space)
 - Public sector

- Environment, including the following topics:
 - Air quality
 - Water and sanitation
 - Noise
 - Environmental quality
 - Biodiversity
 - Energy
- Society and culture, including the following topics:
 - Education
 - Health
 - Safety (sub-topics: disaster relief, emergency and ICT)
 - Housing
 - Culture
 - Social inclusion

The indicator type indicates the "applicability" of the indicator itself. In total, two indicator types are defined and explained below:

- The core indicators can be used by all cities globally.
- The additional indicators may be used by some cities according to their economic capacity, population growth, geographic situation, etc. Also, some additional indicators are very "smart" and can be addressed by "smarter" cities. These indicators are optional, especially for city self-benchmarking.

Using the area, the topic, and the type, the indicators are assigned a unit which indicates how they are measured; a definition which informs about what they describe. Figure 1 shows areas and topics of KPIs for SSC.

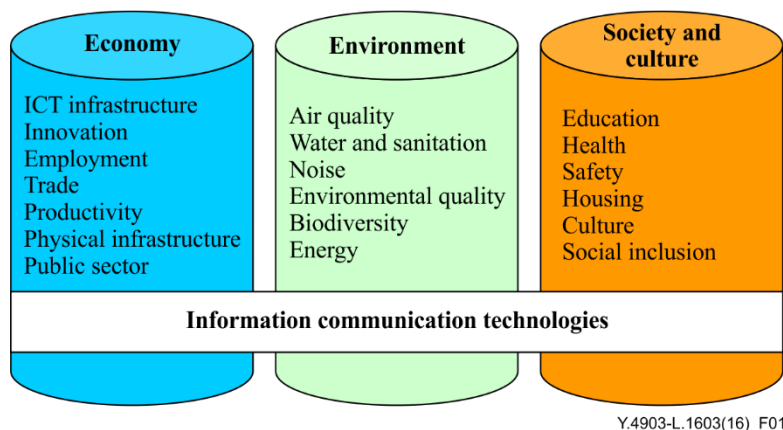


Figure 1 – Areas and topics of KPIs for SSC

7.2 Description of areas and topics of KPIs

7.2.1 Economy

The evaluation of the sustainability of the economy in SSC should be based on seven topics: ICT infrastructure (T1.1), innovation (T1.2), employment (T1.3), trade (T1.4), productivity (T1.5), physical infrastructure (T1.6) and public sector (T1.7). It is necessary to investigate whether or not SSC help to boost the local economy.

T1.1 ICT infrastructure

ICT infrastructure is the basis for other ICT solutions which are the enablers of smart sustainable cities. ICT infrastructure includes terminals and access and network as well as services and information platforms. Typical indicators of ICT infrastructure should take into account the use and/or deployment of various terminals (computer, mobile phone, tablet, etc.), Internet, wireless/fixed broadband, backbone network, cloud computing platform, data centre, etc.

T1.2 Innovation

The city's ability for innovation should be evaluated through multiple perspectives in order to indicate whether it is an innovative city. Innovative cities imply cities that can adjust to changes quickly and play a role as regional leaders. Innovation can be measured directly by research and development investment as well as research and development output which is well indicated in the form of patents produced.

T1.3 Employment

Employment rate is a good indicator of the health of a city economy. Employment includes both formal and informal employment in a city.

T1.4 Trade

Trade can be considered the heart of commercial prosperity. Trade can be measured in terms of exports and imports. E-commerce is also a good indicator of trade in SSC.

T1.5 Productivity

In the context of SSC the evaluation of productivity should focus on the use of information and media, product and process innovation and business and service leadership.

T1.6 Physical infrastructure

To make a city smarter and more sustainable, physical infrastructure should be improved in the following categories: water supply, electricity, health infrastructure, transport, road infrastructure, buildings and urban planning and public space, etc.

T1.7 Public sector

The public sector is the part of the economy concerned with providing various governmental services. ICT use for improving the efficiency of these services should be a prime consideration for SSC.

7.2.2 Environment

The sustainability of the environment in SSC can be considered based on the following six categories: air quality (T2.1), water and sanitation (T2.2), noise (T2.3), environmental quality (T2.4), biodiversity (T2.5) and energy (T2.6).

T2.1 Air quality

This category looks into the quality of air, which is an important area for consideration in many cities. One of the main concerns of city inhabitants is air pollution, which should be accurately monitored and its related data transparently made available to the public. Another aspect of air quality is the CO₂-e emissions of the city where "-e" is "equivalent" and every other greenhouse gas is converted into CO₂.

T2.2 Water and sanitation

From the perspective of environmental protection, water should be considered in the following aspects: water resources, water distribution, water saving, waste water treatment, drainage, sanitation, etc.

T2.3 Noise

This category considers noise exposure level in the city.

T2.4 Environmental quality

The environmental quality can be evaluated through quantitative or qualitative methods in the following aspects: solid waste, electromagnetic fields, green areas and public spaces.

T2.5 Biodiversity

Biodiversity is complicated to measure. At the city level it can be covered by several aspects such as native species and the natural environment for protecting these species.

T2.6 Energy

This category considers the energy use of the city, including electricity consumption, renewable energy consumption as well as energy saving measures in households.

7.2.3 Society and culture

The sustainability of the area society and culture in SSC can be considered based on performance in the following six sectors: education (T3.1), health (T3.2), safety (T3.3), housing (T3.4), culture (T3.5) and social inclusion (T3.6).

T3.1 Education

Education and training is critical to enhance human creativity and to improve the quality of human resources. The assessment of education improvement can be conducted through the following aspects: education investment, use of ICT as assistance, student capability improvement, adult literacy, etc.

T3.2 Health

Generally health can be considered as health care and medical services. In a city health should be evaluated from the following perspectives: health administration (disease control, epidemic prevention and immunity, investment and distribution of medical resources, etc.), health service organization (hospital, pharmacy, health care centre, health insurance, etc.), and health status of city inhabitants (life expectancy, morbidity, mortality, etc.).

T3.3 Safety

Security and safety have been the basic civil services guaranteed by administrators since early times. Security concerns nowadays mainly pertain to man-made threats, specifically crime and terrorism. Safety refers to actions taken in response to natural disasters and accidents. ICTs play a vital role in these two areas.

T3.4 Housing

This category concerns the average living space and/or expenditure in SSC. At city level it is also very important to reduce slums as a sustainable development goal (SDG) of poverty eradication [UN Resolution 288].

T3.5 Culture

SSC assessment concerning cultural aspects focuses on culture/knowledge infrastructure such as libraries, theatres, museums, galleries, etc.

T3.6 Social inclusion

Equity and social inclusion in SSC should be sampled in the following sectors: equity of income/consumption, social and gender equity of access to services and infrastructure, openness and public participation and governance. Governance and public service have a great influence on



social development. It is obvious that modern governments should be open and highly efficient. Otherwise, frequent turbulence could jeopardize stability and development. In this category, ICT will also be evaluated as to whether or not it is helping improve social harmony and administrative efficiency.

8 Key performance indicators of SSC

As mentioned before, the indicator typology indicates the "applicability" of the indicator itself. Each indicator is labelled (Cx.y.z), where (i) x denotes the area, (ii) y the topic and (iii) z the indicator.

NOTE 1 – In this Recommendation the *e-service* concept (e.g., e-health and e-governance, etc.) is used in an inclusive way and refers to both wired and wireless services that benefit the cities and city inhabitants. The mobile wireless services could also be referred to as *m-services* (e.g., m-health and m-banking etc.). These ICT services and goods are also collectively known as *smart services* (e.g., smart grid and smart lighting etc.) and *smart goods* (e.g., smart meters). In some cases the smart service/goods concept is used instead of *e-service*, if this terminology is more widely adopted for the referred service or goods.

NOTE 2 – In this Recommendation, the term *city inhabitant* is used to refer to the people living in the city.

NOTE 3 – To align with the principles behind the SDGs it is encouraged that indicators are disaggregated where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics.

NOTE 4 – It is good to combine the use of KPIs with other assessment methods (such as perceptions, surveys) to understand the satisfaction level of city stakeholders.

NOTE 5 – In this Recommendation the term GDP it is considered as "GDP with purchasing power parity (PPP) and constant prices".

NOTE 6 – This Recommendation identifies the KPIs related to ICT adoption and use in the context of SSC but does not provide any quantification method. Quantification methods will be provided separately.

8.1 Economy

This clause lists the core indicators defined for the economy area.

There are 13 indicators in this area covering Internet access, computer, research and development expenditure, patents, employment, labour productivity and water and electricity metering, reliability of electricity system, public transport network, road traffic and its information.

Topic	Indicator name	Description	Unit of measure	Notes	Mapping to SDG goals and targets
T1.1 ICT infrastructure	C1.1.1 Internet access in households	Proportion of households with Internet access	%	NOTE 1 – This should align with ITU-T reporting requirements. [b-ITU-D IDI] NOTE 2 – For any household member via a fixed or mobile network at any given time. NOTE 3 – The data may be collected from local statistics department, or may need to be extrapolated from national data. NOTE 4 – Annual surveys of households may be another method for data collection to obtain the proportion of households with Internet access. This proportion will then be applied to the in-scope population. NOTE 5 – SDG indicator 17.8.1 is "Proportion of individuals using the Internet". [b-UN SDG]	9.c 17.8
T1.1 ICT infrastructure	C1.1.2 Household with a computer	Proportion of households with at least one computer	%	NOTE 1 – This should align with ITU-T reporting requirements. [b-ITU-D IDI] NOTE 2 – Computer refers to a desktop computer, laptop (portable) computer, tablet, similar handheld computer, etc. NOTE 3 – The data may be collected from local statistics department, or may need to be extrapolated from national data	9.c
T1.2 Innovation	C1.2.1 Research and development expenditure	Research and development expenditure as a proportion of city GDP	%	NOTE 1 – Research and development is defined to include activities that systematically use research findings and expand the frontier of knowledge. [b-UNECE R and D] NOTE 2 – Data collection methodology for this indicator could be adapted from the Frascati manual (an internationally recognised methodology for collecting research and development stats). [b-Frascati]	9.5