Draft new Recommendation ITU-T L.1603
(ex L.KPIs-SSC-SDGs)

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

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Summary

This Draft Recommendation gives general guidance to cities and provides Key Performance Indicators (KPIs) for Smart Sustainable Cities (SSCs) to help cities achieve Sustainable Development Goals (SDGs). It has been jointly developed with UNECE and other UN agencies.

Keywords

Cities, Information Communication Technologies (ICTs), Key Performance Indicators (KPIs), Smart Sustainable Cities (SSCs), Sustainable Development Goals (SDGs), Sustainable Urban Development.

Introduction

This document is the outcome of the joint work and presents a proposal for a Draft ITU-T Recommendation on KPIs for SSCs to assess the achievement of SDGs developed jointly by UNECE, ITU and other UN agencies. It is directly based on the series of Recommendations and Supplements on SSC KPIs [ITU-T L.1600] [ITU-T L.1601] [ITU-T L.1602] [ITU-T L Suppl.19] and the UNECE Smart Cities Indicators [b-UNECE indicators]. It 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] and other sources.

Appendix III reports other useful information and the development history of KPIs.

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

1 Scope

This Draft Recommendation outlines the key performance indicators (KPIs) in the context of smart sustainable cities (SSCs) 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.

This Draft 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 SSCs.
- Development and operation organizations of SSCs, including planning units, SSCs-related producers and service providers, operation and maintenance organizations, helping them to fulfil the tasks of sharing information related to the use of 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 SSCs.

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 following recommended indicators in order to improve their performance.

This Draft Recommendation lists the core indicators that have been selected to be applicable for all cities. The goals for moving towards increased smartness and sustainability differs between cities. Thus, based on their economic power or/and population growth etc, the cities may also select appropriate additional indicators among those listed in Appendix I.

This Draft Recommendation focuses on general development of cities. Cities with particular interest in the ICT development may refer to [ITU-T L.1601] and [ITU-T L.1602].

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 L.1600] Recommendation ITU-T L.1600 (2015), *Overview of key performance indicators (KPIs) in smart sustainable cities.*

[ITU-T L.1601] Recommendation ITU-T L.1601 (2015), *Key performance indicators (KPIs) related to the level and usage of information and communication technology (ICT) in smart sustainable cities.*

[ITU-T L.1602] Recommendation ITU-T L.1602 (2015), *Key performance indicators (KPIs) related to the sustainability impacts of information and communication technology (ICT) in smart sustainable cities.*

[ITU-T L Suppl.19] Supplement 19 to ITU-T L.1600 (2015), *Key performance indicators (KPIs) definitions for smart sustainable cities.*

[ITU-T K Suppl.4] Supplement 4 to ITU-T K.91 (2015), *Electromagnetic field consideration in 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 L.1600]**:** An urban geographical area with one (or several) local government and planning authorities.

3.1.2 ICT companies [ITU-T L.1601]: 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 Cities [ITU-T L.1600]: 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, and environmental aspects, as well as cultural aspects.

3.2 Terms defined in this Recommendation

3.2.1 City sustainability: The sustainability of 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 welfare (safety, health, education etc) and inclusiveness 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, transparency, ethics and justice.
- Cultural: The ability to promote cultural identity and adequacy, value and emotional well-being.

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
HLY	Healthy life years
ICTs	Information and Communication Technologies
IP	Internet Protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
KPIs	Key Performance Indicators
LAN	Local Area Network
PHEV	Plug-in Hybrid Electric Vehicle
PM10	Particulate Matter up to 10 micrometres in size
PM2.5	Particulate Matter up to 2.5 micrometres in size
PPP	Purchasing Power Parity
QoL	Quality of Life
R&D	Research and Development
REEV	Range Extended Electric Vehicle
REX	Range EXtender
SDG	Sustainable Development Goals
SMEs	Small and Medium-sized Enterprises
SSC	Smart Sustainable Cities
TCP	Transmission Control Protocol
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UN-Habitat	United Nations Human Settlements Program
WHO	World Health Organisation

5 General principles for Key Performance Indicators (KPIs) in a city context

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 cities according to 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 the 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 in 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 certain 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. And KPIs are able to deal with emerging issues in SSC construction.

6 Overview of Key Performance Indicators

6.1 Definition of area, topic and type of KPIs

This ITU-T Recommendation on KPIs is based on the series of Recommendations and Supplements on SSC KPIs [ITU-T L.1600] [ITU-T L.1601] [ITU-T L.1602] [ITU-T L Suppl.19] and the UNECE smart cities indicators [b-UNECE indicators]. It 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 area, topic and type 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, health infrastructure, electricity, 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 typology 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 typology, the indicators are assigned a unit which indicates how they are measured; a definition which informs about what they describe.

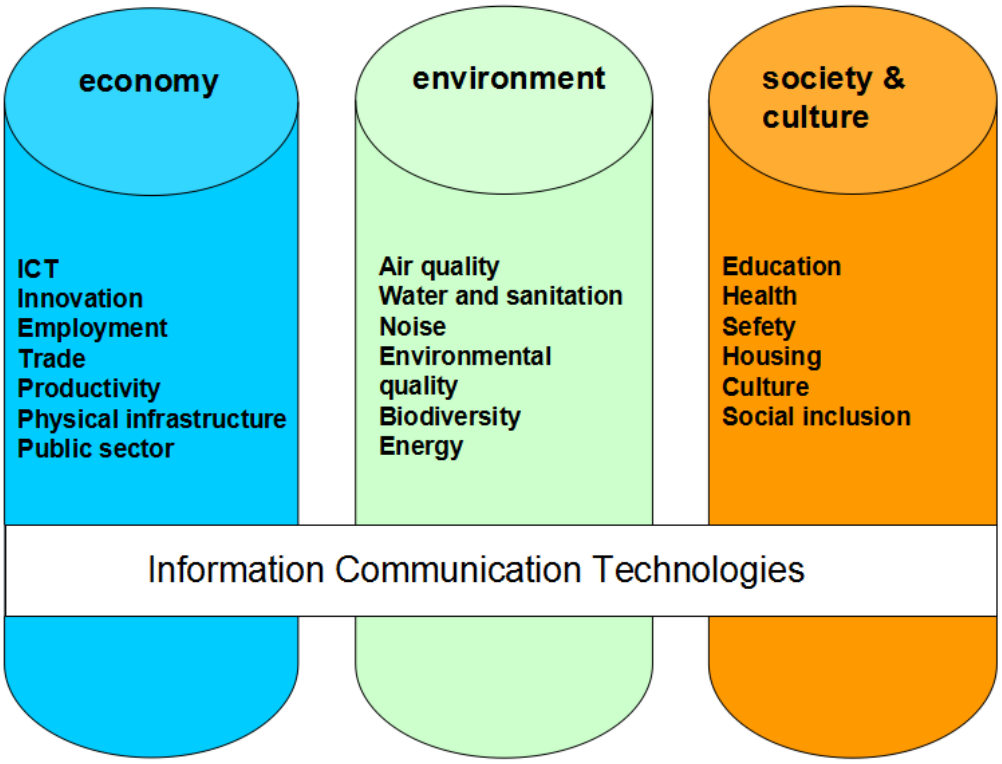

Figure 1 – Areas and topics of KPIs for SSCs

6.2 Description of areas and topics of KPIs

6.2.1 Economy

The sustainability of the economy in SSCs would be evaluated 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 SSCs help to prime the pump of the local economy.

T1.1 ICT infrastructure

ICT infrastructure is the basis for other ICT solutions which are the enabler of smart sustainable cities. It includes terminals, access and network as well as services and information platforms. The 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 center etc.

T1.2 Innovation

The city's ability of innovation should be evaluated through multiple perspectives. It would indicate whether it is an innovative city. Innovative city refers to cities that can adjust to changes quickly and play as a regional lead. Innovation can be measured directly by R&D investment as well as R&D output which is well indicated as patents.

T1.3 Employment

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

T1.4 Trade

Trade can be considered a vein of commercial prosperity. This topic can be measured by exports and imports. E-commerce is also a good indicator for SSCs.

T1.5 Productivity

The promotion of productivity should be focus on widespread use of information and media, product and process innovation, and business and service leadership in the context of SSCs.

T1.6 Physical infrastructure

To make a city smarter and more sustainable, physical infrastructure should be improved in the following categories: water supply, electricity, healthcare, 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 taken into prime consideration for SSCs.

6.2.2 Environment

The sustainability of environment in SSCs 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 part 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 been transparently made available to the public. Another aspect of air quality is the CO_2-e emissions of the city where "-e" is "equivalent" and every other greenhouse gas is converted into CO_2.

T2.2 Water and sanitation

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

T2.3 Noise

This part looks into 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 field, 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 natural environment for protecting these species.

T2.6 Energy

This part looks into the energy use of the city, including electricity consumption, renewable energy consumption as well as energy saving measures in households.

6.2.3 Society and culture

The sustainability of the area society and culture in SSCs can be considered based on the 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 in the following aspects: education investment, use of ICT as an assistance, student capability improvement, adult literacy etc.

T3.2 Health

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

T3.3 Safety

Security and safety has been the basic civil services guaranteed by administrators since dateless 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 part is about the average living space and/or expenditure in SSCs. 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

SSCs assessment concerning the cultural aspects focus on culture/knowledge infrastructure such as libraries, theatres, museums, galleries etc.

T3.6 Social inclusion

Equity and social inclusion in SSC would 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 would jeopardize stability and development. In this part, ICT will also be evaluated whether or not helping improve social harmony and administrative efficiency.

7 Key performance indicators of SSCs

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

NOTE 1 – In this document 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, m-banking etc.). These ICT services and goods are also collectively known as *Smart services* (e.g., Smart grid, Smart lighting) 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 document, 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 document with the term GDP it is considered “GDP with Purchasing Power Parity (PPP) and constant prices”.

7.1 Economy

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

There are 13 indicators in this area covering *Internet access, computer, R&D expenditure, Patents, Employment, labour productivity, 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 SDGs goals and targets
T1.1 ICT infrastructure	C1.1.1 Internet access in households	Percentage of households with Internet access	%	NOTE 1 – This should align with ITU-T reporting requirements. 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 percentage of households with Internet access. This percentage will then be applied to the in-scope population. NOTE 5 – SDG indicator 17.8.1 is "Proportion of individuals using the Internet".	9.c 17.8
T1.1 ICT infrastructure	C1.1.2 Household with a computer	Percentage of households with at least one computer	%	NOTE 1 – This should align with ITU-T reporting requirements. NOTE 2 – Computer refers to a desktop computer, laptop (portable) computer, tablet, similar handheld	9.c

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				computer, etc. NOTE 3 – The data may be collected from local statistics department, or may need to be extrapolated from national data	
T1.2 Innovation	C1.2.1 R&D expenditure	Research and Development expenditure as a percentage of city GDP	%	NOTE 1 – R&D is defined to include activities that systematically use research findings and expand the frontier of knowledge. [b-UNECE R&D] NOTE 2 – Data collection methodology for this indicator could be adapted from the Frascati manual (an internationally recognised methodology for collecting R&D stats). [b-Frascati] NOTE 3 – SDG indicator 9.5.1 is "Research and development expenditure as a percentage of GDP".	9.5
T1.2 Innovation	C1.2.2 Patents	Number of new patents granted per 100 000 capita per year	No. / 100 000 inhabitants / year	NOTE 1 – Calculate as Numerator: the total number of new patents issued to residents and organizations of the city. Denominator: One 100,000th of the city's population.	9.b
T1.3 Employment	C1.3.1 Employment rate	Employment rate.	%	NOTE 1 – Employment rate as reported by local/ national official body. NOTE 2 – SDG 8.5.2 is "Unemployment rate by sex, age group and people with disabilities".	8.5
T1.5 productivity	C1.5.1 Labour productivity	Value added per person employed.	$/hours	NOTE 1 – Value added per person employed is generally referred to as labour productivity.	8.2 2.3

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				NOTE 2 – Calculate as : Numerator: GDP of the city. Denominator: Labor hours worked. NOTE 3 – SDG 8.2.1 is "Annual growth rate of real GDP per employed person".	
T1.6 Physical infrastructure – Water Supply	C1.6.1 Availability of smart water meters	Proportion of the water consumers (including households, companies, etc) with smart water meters.	%	NOTE 1 – Calculate as : Numerator: Number of smart water meters. Denominator: Total number of water meters.	9.1
T1.6 Physical infrastructure – Electricity	C1.6.2 Availability of Smart electricity meters	Proportion of the electricity consumers (including households, companies, etc) with smart electricity meters.	%	NOTE 1 – Calculate as : Numerator: Number of smart electricity meters. Denominator: Total number of electricity meters.	9.1
T 1. 6 Physical infrastructure – Electricity	C 1.6.3 Electricity system outage frequency	Average number of electrical interruptions per customer per year	No.	NOTE 1 – This is also known as SAIFI - System Average Interruption Frequency Index (dimensionless number) NOTE 2 – Calculate as : Numerator: Total number of customer interruptions. Denominator: Total number of customers served.	7.b

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T1.6 Physical infrastructure – Electricity	C 1.6.4 Electricity system outrage time	Average length of electrical interruptions	minutes	NOTE 1 – This is also known as CAIDI – Customer Average Interruption Duration Index (In minutes) NOTE 2 – Calculate as : Numerator: Sum of all customer interruption durations Denominator: Total number of customers interruptions.	7.b
T1.6 Physical infrastructure – Transport	C1.6.5 Public transport network	Length of public transport systems per 100 000 inhabitants.	km / 100 000 inhabitants	NOTE 1 – Public Transport should include both high capacity (e.g. heavy rail, metro, subway systems and commuter rail systems) and light capacity (e.g. light rail streetcars and trams, buses, trolleybuses). NOTE 2 – Calculate as Numerator : km (one way length). Denominator : One 100,000th of the city's population. Express as km / 100,000 inhabitants. NOTE 3 – One way length is defined as a transit line that is 10 km long (back and forth) is counted as 10km (one way length) vs 20 km (two way length).	11.2
T1.6 Physical infrastructure – Transport	C1.6.6 Road traffic efficiency	Travel Time Index	Ratio	NOTE 1 – Travel Time Index (TTI) is a measure of congestion that focuses on each trip and each distance of travel and relates to traffic efficiency. NOTE 2 - Ratio of the travel time during the peak period to the time required to make the same trip at	11.2

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				free-flow speeds. NOTE 3 – Calculate as Numerator: Travel time in the peak period. Denominator: Travel time in free-flow. Expressed as a ratio.	
T1.6 Physical infrastructure – Transport	C1.6.7 Real-time public transport information	Percentage of public transport stops and stations with real-time traffic information available	%	NOTE 1 – Calculate as: Numerator: Number of stops and stations with real time information. Denominator: Total number of stops and stations. NOTE 2 - Via electronic bus bulletin boards, smartphone apps etc.	11.2

7.2 Environment

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

There are 19 indicators in this area covering *air quality, CO_2 emissions, water resource, waste water collection and treatment, sanitation, solid waste collection and treatment, city green areas, noise monitoring, native species monitoring, EMF, and renewable energy etc.*

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T2.1 Air quality	C2.1.1 Air pollution	Air quality index (AQI) based on : Particulate matter (PM10, and PM2.5),	No.	NOTE 1 – This indicator should be measured as annual mean levels of AQI. NOTE 2 – Average concentrations can demonstrate long term exposure (chronic) while days exceeding	11.6 12.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
		NO_2 (nitrogen dioxide), SO_2 (sulphur dioxide), O_3 (ozone), and CO (carbon monoxide).		demonstrates short term (acute) exposure each of which have different impacts on the population. Concentration can be expressed as: PM 2.5 (µg/m3), PM 10 (µg/m3), NO_2 (nitrogen dioxide) (µg/m3), SO_2 (sulphur dioxide) (µg/m3), O_3 (ozone) (µg/m3), and CO (carbon monoxide) (µg/m3). NOTE 3 – SDG indicator 11.6.2 is "Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)"	
T2.1 Air quality	C2.1.2 GHG emissions (*)	Greenhouse gas emissions per capita.	eCO_2 / capita	NOTE 1 – Methodologies for determining GHG emissions include but not limited to: The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). BSI Norm: PAS 2070 on Specification for the assessment of greenhouse gas emissions of a city. Intergovernmental Panel on Climate Change IPCC Guidelines for National Greenhouse Gas Inventories Global Protocol for Community-Scale GHG Emissions' (GPC), (2012 Accounting and Reporting Standard) NOTE 2 – This indicator can be subdivided into major city sectors (transportation, industry, commercial buildings, residential buildings, etc.)	7.a 11.6
T2.2 Water and Sanitation	C2.2.1 Quality of drinking water	Index of compliance with standards relating to water quality parameters	% compliance	NOTE 1 – For this indicator to be implemented there will be a need to define what is considered to be an acceptable standard for water quality and a definition as to the minimum sampling required.	6.3 6.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
		for drinking water.		Preferable Reference: World Health Organisation (WHO) Guideline for Drinking-water Quality. [b-WHO water] As alternative National reference can be used. NOTE 2 – SDG indicator 6.3.2 is "Percentage of bodies of water with good ambient water quality". NOTE 3 – SDG indicator 6.4.2* may be "Percentage of total available water resources used, taking environmental water requirements into account (level of water stress)".	
T2.2 Water and Sanitation	C2.2.2 Access to improved water source	Percentage of city population with sustainable access to improved water sources	%	NOTE 1 – Calculate as: Numerator : Number of city inhabitants with improved water sources. Denominator: Total city population. NOTE 2 – Improved water sources include: piped water, public tap, borehole or pump, protected well, protected spring or rainwater. http://www.unwater.org/downloads/TFIMR_Annex_FinalReport.pdf NOTE 3 – SDG indicator 6.1.1 is "Percentage of population using safely managed drinking water services".	6.1 1.4
T2.2 Water and Sanitation	C2.2.3 Water Consumption	Water consumption per capita	l / day / capita	NOTE 1 – Calculate as: Numerator: Total amount of water consumption (l /day)	6.1 1.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				Denominator: Total number of city inhabitants. Express as : l / day / capita. http://www.unwater.org/downloads/TFIMR_Annex_FinalReport.pdf NOTE 2 – SDG indicator 6.1.1 is "Percentage of population using safely managed drinking water services".	6.4
T2.2 Water and Sanitation	C2.2.4 Wastewater treated	Percentage of wastewater receiving treatment.	%	NOTE 1 – Calculate as: Numerator : Total amount of wastewater that has undergone (primary /secondary / tertiary) treatment. Denominator: Total amount of wastewater produced in the city and collected. NOTE 2 – Calculation of this Indicator should be made on each level of treatment separately. http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/freshwater/waste_water_treatment.pdf Primary: physical separation of suspended solids using primary clarifiers. Secondary: After primary treatment to remove or reduce contaminants or growths with a focus on Biological Oxygen Demand (BOD) Tertiary: After secondary treatment for further reductions in Biological Oxygen Demand (BOD) levels and other oxygen-demanding substances in the wastewater, remove nitrogen and phosphorus and	6.3 12.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				including other separation techniques such as carbon adsorption, flocculation/precipitation, membranes for advanced filtration, ion exchange, chlorination, dechlorination , reverse osmosis, etc. NOTE 3 – SDG indicator 6.3.1 is "Percentage of wastewater safely treated". NOTE 4 – SDG indicator 12.4.2* may be "Treatment of waste, generation of hazardous waste, hazardous waste management, by type of treatment".	
T2.2 Water and Sanitation	C2.2.5 Wastewater collection	Percentage of households served by wastewater collection	%	NOTE 1 – Calculate as : Numerator: Number of households served by wastewater collection. Denominator: Total number of households.	6.3 1.4
T2.2 Water and Sanitation	C2.2.6 Household sanitation	Percentage of the households with access to improved sanitation facilities	%	NOTE 1 – Calculate as : Numerator: Total number of households using improved sanitation and facilities. Denominator: Total number of households. NOTE 2 – Improved facilities include: • Flush or pour-flush to piped sewer system, septic tank or pit latrine, • Ventilated improved pit latrine, • Pit latrine with slab • Composting toilet http://www.unwater.org/downloads/TFIMR_Annex_FinalReport.pdf	6.2 1.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				NOTE 3 – SDG indicator 6.2.1 is "Percentage of population using safely managed sanitation services, including a hand-washing facility with soap and water".	
T2.3 Noise	C2.3.1 Exposure to noise	Percentage of the city inhabitants exposed to noise levels above international/national exposure limits.	%	NOTE 1 – Relevant standards include : ISO 1996-2:1987. ISO/TS 15666:2003.	
T2.4 Environmental quality	C2.4.1 Compliance with WHO endorsed exposure guidelines	Application of WHO endorsed exposure guidelines for ICT installations in the city	YES/NO	NOTE 1 – WHO endorsed exposure guidelines are referred to in [ITU-T K Suppl.4]. NOTE 2 – ICT devices are regulated nationally and are not included.	
T2.4 Environmental quality	C2.4.2 Adoption of a consistent planning approval process with respect to EMF	Application of a consistent planning approval process with respect to EMF to enable efficient deployment of ICT systems	YES/NO	NOTE 1 – A consistent planning approval process between cities is preferred to individual city requirements to ensure efficient deployment [ITU-T K Suppl.4].	
T2.4 Environmental quality	C2.4.3 Availability of EMF information	Availability of information for the public and other stakeholders and referencing WHO	YES/NO	NOTE 1 – EMF-related information is referred to in [ITU-T K Suppl.4].	

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
		and ITU resources regarding compliance, health and installation issues.			
T2.4 Environmental quality	C2.4.4 Solid waste collection	Percentage of city population with regular solid waste collection.	%	NOTE 1 – Calculate as: Numerator: Number of city inhabitants that are served by solid waste collection. Denominator: Total number of city inhabitants. NOTE 2 – SDG indicator 11.6.1 is "Percentage of urban solid waste regularly collected and with adequate final discharge with regard to the total waste generated by the city". NOTE 3 – SDG indicator 12.4.2* may be "Treatment of waste, generation of hazardous waste, hazardous waste management, by type of treatment".	11.6 12.4 1.4
T2.4 Environmental quality	C2.4.5 Solid waste treatment	Percentage of solid waste: a) disposed to sanitary landfills; b) burnt in an open area; c) incinerated; d) disposed to an open dump; e) recycled; f) other with regard to total amount of solid waste produced.	%	NOTE 1 – Each treatment should be reported separately. NOTE 2 – Calculate as: Numerator: Total amount of solid waste that is (disposed to landfills / incinerated/ burnt in an open area / disposed in an open dump / other/ recycled) (tonnes). Denominator: Total amount of solid waste produced (tonnes).	11.6 12.4 1.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				NOTE 3 – SDG indicator 11.6.1 is "Percentage of urban solid waste regularly collected and with adequate final discharge with regard to the total waste generated by the city". NOTE 4 – SDG indicator 12.4.2* may be "Treatment of waste, generation of hazardous waste, hazardous waste management, by type of treatment".	
T2.4 Environmental quality	C2.4.6 Green areas and public spaces	Publically accessible green areas and public spaces per 100 000 inhabitants.	m^2 / 100,000 inhabitants	NOTE 1 – Green space includes parks, & nature areas that are publically accessible. NOTE 2 – Calculate as : Numerator: Total area of green space in the city. Denominator: One 100,000th of the city's population. Express as: m^2 / 100,000 inhabitants. NOTE 3 – SDG indicator 11.7.1 is "The average share of the built-up area of cities that is open space for public use for all, disaggregated by age group, sex and persons with disabilities".	11.7
T2.5 Biodiversity	C2.5.1 Native species monitoring	Change of number of native species	no.	NOTE 1 – Taxonomic groups include: Plants, birds and butterflies, mammals, insects, etc. NOTE 2 – Methodology is described in the User's Manual for the City Biodiversity Index.[b-CBD manual] Expressed as number of native species increased: 0: maintaining or a decrease in the number of species,	2.5 15.5

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				1: 1 species increase, 2: 2 species increase, 3: 3 species increase, 4: 4 species or more increase. NOTE 3 – Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, etc. NOTE 4 – SDG indicator 15.5.1 is “Red list index”.	
T2.6 Energy	C2.6.1 Access to Electricity	Percentage of households with access to electricity	%	NOTE 1 – Calculate as : Numerator: Number of households in the city with an connection to the electrical system. Denominator: Total number of households. NOTE 2 – SDG indicator 7.1.1 is “Percentage of population with access to electricity”.	7.1 1.4
T2.6 Energy	C2.6.2 Renewable energy consumption	Percentage of renewable energy consumed in the city.	%	NOTE 1 – Calculate as : Numerator: Total consumption of electricity from renewable sources. Denominator: Total electricity consumption. NOTE 2 – Renewable sources include geothermal, solar, wind, hydro, tide, wave energy, and biomass, etc. NOTE 3 – SDG indicator 7.2.1 is “Renewable energy share in the total final energy consumption”.	7.2

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T2.6 Energy	C2.6.3	Electricity consumption per capita	kWh / day / capita	NOTE 1 – Calculate as : Numerator: Total consumption of electricity. Denominator: Number of city inhabitants. Express as kWh / day / capita.	

7.3 Society and culture

This clause lists the core indicators defined for Society and culture area.

There are 20 indicators in this area, covering: *student ICT capability, adult literacy, school enrollment, higher education, health records, sharing of medical resources, life expectancy, maternal mortality, doctors, city resilience plans, emergency response, information security, housing expenditure, informal settlements, connected libraries, cultural infrastructure, cultural resources online, public participation, gender income equity, and opportunities for people with special needs*.

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T3.1 Education	C3.1.1 Students ICT access	Percentage of students/pupils with classroom access to ICT facilities	%	NOTE 1 – ICT facilities can be measured with Internet connectivity, computer labs, ICT modules, digital learning etc. NOTE 2 – Calculate as Numerator: Students/pupils with classroom access to ICT facilities. Denominator: Total students/pupils enrolled in schools. NOTE 3 – Students/pupils refer to school - aged population enrolled in primary and secondary schools. NOTE 4 – Cities are encouraged to collect data both from public	4.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				and private schools. NOTE 5 – SDG indicator 4.4.1 is "Percentage of youth/adults with information and communication technology (ICT) skill by type of skill".	
T3.1 Education	C3.1.2 Adult literacy	Adult literacy rate	%	NOTE 1 – Adult literacy rate is defined as "the percentage of population aged 15 years and over who can both read and write with understanding a short simple statement on his/her everyday life. Generally, 'literacy' also encompasses 'numeracy', the ability to make simple arithmetic calculations " [b-ITU-D IDI] NOTE 2 - The data may be collected from local statistics department, or may need to be extrapolated from national data. Express as a percentage. NOTE 3 – SDG indicator 4.6.1 is "Percentage of population in a given group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills.	4.6
T3.1 Education	C 3.1.3 School enrollment	Percentage of school-aged population enrolled in schools	%	NOTE 1 – Calculate as Numerator: Number of students/pupils in primary and secondary levels in public and private schools. Denominator: Total number of the school-aged population.	4.1
T3.1 Education	C3.1.4 Higher education ratio	Percentage of city inhabitants with tertiary education degrees.	%	NOTE 1 – Tertiary education broadly refers to all post-secondary education, including but not limited to universities. Universities are clearly a key part of all tertiary systems, but the diverse and growing set of public and private tertiary institutions in every country—	4.3

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				colleges, technical training institutes, community colleges, nursing schools, research laboratories, centers of excellence, distance learning centers, and many more—forms a network of institutions that support the production of the higher-order capacity necessary for development. http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTEDUCATION/0,,contentMDK:20298183~menuPK:617592~pagePK:148956~piPK:216618~theSitePK:282386,00.html#what_why NOTE 2 – Calculate as Numerator: Number of city inhabitants holding at least one tertiary education degree. Denominator: Total adult population.	
T3.2 Health	C3.2.1 Electronic health records	Percentage of city inhabitants with electronic health records.	%	NOTE 1 – A health record contains information on weight, height, heart rate, BMI, etc.	3.8
T3.2 Health	C3.2.2 Sharing of medical resources	Percentage of hospitals, pharmacies and health care providers using ICT means for sharing of medical resources such as hospital beds, and medical	%	NOTE 1 – Methodologies for sharing medical information include but not limited to: ITU-T H.860; ISO/HL 7 10781; ISO 13606 series; ISO 13119; ISO/TR 14292;	3.8

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
		information, especially electronic health records.		ISO/TR 20514; ISO/TS 29585:2010. NOTE 2 – The data may be collected from local statistics department, or may need to be extrapolated from national data. NOTE 3 - Cities are encouraged to collect data both from public and private medical institutions.	
T3.2 Health	C3.2.3 Life expectancy	Average life expectancy indicates the number of years a newborn infant would live.	Years	NOTE 1 – The data may be collected from local statistics department, or may need to be extrapolated from regional or national data. NOTE 2 – It is also a possibility to extract this data from WHO tables. http://www.who.int/healthinfo/statistics/LT_method.pdf?ua=1&ua=1	
T3.2 Health	C3.2.4 Maternal mortality	Maternal deaths per 100 000 live births	Rate	NOTE 1 – Same as SDG indicator 3.1.1.	3.1
T3.2 Health	C3.2.5 Doctors	Number of doctors per 100 000 inhabitants.	No. / 100 000 inhabitants	NOTE 1 – Calculated as: Numerator: General or specialized doctors working in the city. Denominator: One 100 000th of the city's population. Expressed as the number of doctors per 100,000 inhabitants. NOTE 2 – SDG indicator 3.c.1 is "Health worker density and distribution".	3.c

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T3.3 Safety – Disaster relief	C3.3.1 Resilience plans	Presence of vulnerability assessment, financial (capital and operating) plans and technical systems for disaster mitigation	checklist	NOTE 1 – Checklist: a) city infrastructures available for resilience; b) vulnerability assessment; c)financial (capital and operation) plans to mitigate vulnerabilities; d)technical systems to implement the plans. NOTE 2 – This indicator shall be determined by the sum of YES answers reported. NOTE 3 – Vulnerability to heat, drought, flooding, earthquakes, typhoon, tsunami and other natural hazards are investigated, and adoption of disaster management. NOTE 4 - Data of vulnerability assessment can be derived from historical data (expert interviews) and global maps regarding heat, drought, flooding, earthquakes, typhoon, tsunami, etc. NOTE 5 – reference: the United Nations Office for Disaster Risk Reduction http://www.unisdr.org/ NOTE 6 – SDG indicator 11.b.1* may be "Percentage of cities that are implementing risk reduction and resilience strategies aligned with accepted international framework (such as the successor to the Hyogo Framework for Action 2005-2015 on disaster risk reduction) that include vulnerable and marginalized groups in their design implementation and monitoring".	11 b 13.1 13.2 13.3
T3.3 Safety – Emergency	C3.3.2 Emergency Service Response Time	Average response time for Emergency Services	Minutes	NOTE 1 – Emergency services include police, fire control and others. NOTE 2 – Expressed as the average number of minutes and seconds taken to respond to emergency calls from initial call to arrival on-site.	

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T3.3 Safety - ICT	C3.3.3 Information security and privacy protection	Existence of systems, rules and regulations to ensure information security and privacy protection in public service.	Checklist	NOTE 1 – The verification contains examination in four aspects, including a) legislation; b) regulations enforced in public service and facilities; c) regulations properly enforced for web services; and d) the coverage rate of qualified systems. NOTE 2 – This indicator is determined by the sum of YES answers reported.	
T3.4 Housing	C3.4.1 Housing expenditure	Percentage expenditure of income for housing	%	NOTE 2 – Housing expenditure includes rent, mortgage, utility services, maintenance, energy efficiency repairs, and other repairs. NOTE 1 – Calculate as: Numerator: housing expenditures. Denominator: Total household income.	11.1
T3.4 Housing	C3.4.2 Informal settlements	Proportion of urban population living in slums, informal settlements or inadequate housing	%	NOTE 1 – Same as SDG indicator 11.1.1. NOTE 2 – Informal settlements include slums, informal settlements and inadequate housing as defined by UN-Habitat [b-UN-habitat sett.]	11.1
T3.5 Culture	C3.5.1 Connected libraries	Number of connected libraries per 100 000 population.	No. / 100 000 inhabitants	NOTE 1 – Connected libraries are libraries which offer access to Internet and electronic media and represent an information hub.	9.c 4.4
T3.5 Culture	C3.5.2 Cultural	Number of the cultural institutions	No. / 100 000	NOTE 1 – “Cultural institution” means a public or nonprofit institution within	8.9 11.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
	infrastructure	per 100 000 inhabitants	inhabitants	this state which engages in the cultural, intellectual, scientific, environmental, educational or artistic enrichment of the people of this state. "Cultural institution" includes, without limitation, aquaria, botanical societies, historical societies, land conservation organizations, libraries, museums, performing arts associations or societies, scientific societies, wildlife conservation organizations and zoological societies. "Cultural institution" does not mean any school or any institution primarily engaged in religious or sectarian activities. http://www.oregonlaws.org/glossary/definition/cultural_institution	
T3.5 Culture	C3.5.3 Cultural resources online	Proportion of cultural institutions and events for which online participation is offered.	%	NOTE 1 – Cultural resources online include: events and activities provided online, and watched or listened through electric/virtual media. NOTE 2 – Calculated as : Numerator: Number of cultural institutions and events for which online participation is offered. Denominator: Total number of cultural institutions and events.	11.4
T3.6 Social inclusion	C3.6.1 Public participation	Promotion of inhabitants' participation in public affairs	Checklist	NOTE 1 – Checklist: a) existence of rules and regulations to promote the participation of inhabitants in public affairs; b) existence of systems to promote inhabitants' engagement, such as online information and ICT based feedback mechanism; c) existence of formal participatory process prior to policy making, major public projects etc.; d) existence of public decision-making to ensure gender and aging equity.	16.7

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T3.6 Social inclusion	C3.6.2 Gender income equity	Ratio of Average hourly earnings of female and male employees, by occupation, age group and persons with disabilities	Ratio	NOTE 1 – Calculated as : Numerator: Average hourly earnings of female employees. Denominator: Average hourly earnings of male employees. NOTE 2 – SDG indicator 8.5.1 is "Average hourly earnings of female and male employees, by occupation, age group and persons with disabilities".	8.5 10.4 5.1
T3.6 Social inclusion	C3.6.3 Opportunities for people with special needs	Existence of public services and benefits for people with special needs.	Checklist	NOTE 1 – Public services and benefits checklist: a) Public buildings: infrastructure available; b) Education: higher education possible; c) Jobs: availability; d) ICT: availability of customized services and information. NOTE 2 – People with special needs here indicate indigenous people, and persons with disabilities including age related disabilities. NOTE 3 – SDG indicator 11.2.1 is "Proportion of the population that has convenient access to public transport, disaggregated by age group, sex and persons with disabilities".	11.2 11.7 1.3 4.5 4.a 8.5 10.2

Appendix I

Additional indicators

(This appendix does not form an integral part of this Recommendation.)

This appendix lists additional indicators that cities can select due to their economic power, population growth, geographic condition, etc. Also, some additional indicators are very "smart" and can be addressed by "smarter" cities. Therefore these indicators are optional, especially for self-benchmarking. Each additional indicator is labelled A(x.y.z), where (i) x denotes the area, (ii) y the topic and (iii) z the indicator.

I.1 Economy

There are 21 additional indicators in this area, covering: *electronic wireless and fixed broadband, mobile device, SMEs, creative industry, tourist industry, e-commence, electronic payment, knowledge economy, companies providing online services, water leakages, water supply monitoring, electricity supply monitoring, sporting facilities, EVs, traffic monitoring, public buildings sustainability, urban planning, open data and e-Public service*.

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T1.1 ICT infrastructure	A1.1.1 Wireless broadband subscriptions	Wireless-broadband subscriptions per 100 inhabitants.	No. / 100 inhabitants	NOTE 1 – Wireless broadband subscriptions include wireless broadband through satellite broadband, terrestrial fixed wireless broadband and mobile cellular network subscriptions. NOTE 2 – The data may be collected from local statistics department, or may need to be extrapolated from national data NOTE 3 – SDG indicator 9.c.1 is “Percentage of population covered by a mobile network, by technology”. NOTE 4 – SDG indicator 5.b.1 is “Proportion of individuals who own a mobile telephone, by sex”.	9.c 5.b

T1.1 ICT infrastructure	A1.1.2 Fixed broadband subscriptions	Households with Fixed (wired) broadband.	%	NOTE 1 – Fixed (wired) broadband subscriptions refer to subscriptions for high-speed access to the public Internet (a TCP/IP connection). High-speed access is defined as downstream speed equal to, or greater than, 256 kbits/s. NOTE 2 – Fixed (wired) broadband includes broadband through cable modem, DSL, fiber and other fixed (wired) broadband technologies (such as Ethernet LAN, and broadband-over-power line (BPL) communications). NOTE 3 – Calculated as : Numerator: Households with fixed (wired) broadband. Denominator: Total households. NOTE 4 – Mobile cellular network subscriptions are not included. NOTE 5 – The data may be collected from local statistics department, or may need to be extrapolated from national data.	9.c
T1.1 ICT infrastructure	A1.1.3 Household with a mobile device	Percentage of households with at least one smartphone or similar device	%	NOTE 1 – This should align with ITU-T reporting requirements. NOTE 2 – The data may be collected from local statistics department, or may need to be extrapolated from national data. NOTE 3 – Mobile device refers to a smartphone, and similar device, etc.	9.c

T1.2 Innovation	A1.2.1 SMEs	Percentage of small and medium-sized enterprises (SMEs)	%	NOTE 1 – Calculate as : Numerator: Number of SMEs. Denominator: Total number of enterprises. NOTE 2 – SDG indicator 9.3.1 is "Percentage of small-scale industries with a total industry value added".	9.3 8.3
T1.3 Employment	A1.3.1 Creative industry employment	Percentage of employees working in the creative industry	%	NOTE 1 – Creative industries refer to those ones that are based on individual creativity, skill and talent with the potential to create wealth and jobs through developing intellectual property. This includes thirteen sectors: advertising, architecture, the art and antiques market, crafts, design, designer fashion, film, interactive leisure software (i.e., video games), music, the performing arts, publishing, software, and television and radio. http://s3platform.jrc.ec.europa.eu/documents/20182/84453/120420_CCI_Policy_Handbook_(FINAL).pdf NOTE 2 – Expressed as a percentage.	
T1.3 Employment	A1.3.2 Tourism industry employment	Percentage of employees working in the tourism industry	%	NOTE 1 – SDG indicator 8.9.1* may be "Tourism direct GDP (as a percentage of total GDP and in growth rate); and number of jobs in tourism industries (as a percentage of total jobs and growth rate of jobs, by sex)".	8.9

T1.4 Trade – e-Commerce	A1.4.1 e-commerce purchase ratio	Percentage of population using e-commerce for purchase	%	NOTE 1 – 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.	
T1.4 Trade – e-Commerce	A1.4.2 Electronic and mobile payment	Electronic payments system usage per 100 city inhabitants.	No. / 100 inhabitants		
T1.4 Trade – Export/import	A1.4.3 Knowledge-intensive export/import	Percentage of exports/imports of knowledge-intensive goods and services.	%	NOTE 1 – Knowledge-intensive goods and services refers to OECD reports [b-OECD KE]	
T1.5 Productivity	A1.5.1 Companies providing online services	Percentage of registered companies providing online services	%	NOTE 1 – online services include e-commerce, e-learning, e-entertainment, cloud computing etc. NOTE 2 – Calculate as: Numerator: Number of registered companies providing online serviced (including e-commerce, e-learning, e-entertainment, cloud computing etc.). Denominator: Total registered companies within the city.	
T1.6 Physical infrastructure — Water Supply	A1.6.1 Water Supply loss	Percentage of water leak in the water distribution system.	%	NOTE 1 – Calculate as: Numerator: Volume of water supplied minus the volume of utilized water. Denominator: Total volume of water supplied.	9.1 9.4

T1.6 Physical infrastructure — Water Supply	A 1.6.2 Water Supply ICT Monitoring	Percentage of the water distribution system monitored by ICT	%	NOTE 1 – Calculate as: Numerator: length of water distribution system monitored by ICT. Denominator: length of water distribution system.	
T1.6 Physical infrastructure — Electricity Supply	A 1.6.3 Electricity supply system management using ICT	Proportion of power substation and user points under automatic inspection using ICT.	%	NOTE 1 – Calculate as: Numerator: Number of power substation and user points under automatic inspection using ICT. Denominator: Total number of power substation and user points.	
T1.6 Physical infrastructure – Health infrastructure	A1.6.4 Sporting facilities	Area of total public sports facilities per 100 000 inhabitants.	m^2 / 100 000 inhabitants	NOTE 1 – Calculate as: Numerator: m^2 total public sports facilities (free and paid). Denominator : One 100,000th of the city's population.	
T1.6 Physical infrastructure – Transport	A1.6.5 Share of EVs	Percentage of EVs (BEV, PHEV, REEV/REX, FCEV) in public fleets.	%	NOTE 1 – Calculate as: Numerator: Number of EVs. Denominator: Total number of vehicles.	
T1.6 Physical infrastructure – road infrastructure	A1.6.6 Traffic monitoring	Percentage of major streets monitored by ICT	%	NOTE 1 – Refer to major and arterial roads and highways. NOTE 2 – Calculate as: Numerator: Length of major streets monitored by ICT. Denominator: Total major streets.	9.1

T1.6 Physical infrastructure – road infrastructure	A1.6.7 Pedestrian infrastructure	Portion of city with pedestrian, car free and traffic calming streets	km / km ^{2}	NOTE 1 – Calculate as: Numerator: Total length of pedestrian, car free and traffic calming streets. Denominator: Total city area.	
T1.6 Physical infrastructure – building	A1.6.8 Public building sustainability	Percentage of public buildings with sustainability certifications	%	NOTE 1 – Calculate as : Numerator: Area of public buildings with certification to a recognized standard for ongoing building operations. Denominator: Total area of public buildings. NOTE 2 – Standards include: BREEAM, LEED, CASBEE, BOAM BEST, BCA Green Mark, etc.	11.c
T1.6 Physical infrastructure – urban planning and public space	A1.6.9 Urban development and spatial planning	Existence of a strategic city planning documents promoting compact development, mixed urban land use; and avoiding urban sprawl	Yes/ No	NOTE 1 – SDG indicator 11.a.1* may be "Cities with more than 100'000 inhabitants that implement urban and regional development plans integrating population projections and resource needs".	11.3 11.a
T1.7 Public Sector	A1.7.1 Open data	Percentage of available open data of cities.	%	NOTE 1 – Calculate as: Numerator: Total number of open data sets published. Denominator: Total number of open data sets that could be published following national rule.	
T1.7 Public Sector	A 1.7.2 e- Public Services adoption	Percentage adoption of electronic public services	%	NOTE 1 – Calculate as: Numerator: Number of public service transactions conducted online. Denominator: Total number of public service transactions (online and offline).	

I.2 Environment

There are 9 additional indicators in this area, covering *air pollution monitoring, water saving, drainage system management, noise monitoring, recycling of solid waste, protected natural area, renewable energy generation, energy saving, and public building energy consumption.*

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T2.1 Air quality	A2.1.1 Air pollution monitoring system	Number of outdoor installations of ICT based air quality monitoring systems per km^2	No. / km^2	NOTE 1 – ICT based systems refer to air quality monitoring systems with sensors, which transmits measurements to a database where daily alerts and information are available and yearly summaries for each monitoring stations are computed. NOTE 2 – Calculate as: Numerator: Total number of outdoor installations of ICT based monitoring system Denominator: Total city surface area	11.6 12.4
T2.2 Water and Sanitation	A2.2.1 Water saving in households	Percentage of households with water saving installations.	%	NOTE 1 – Calculate as: Numerator: number of households with water saving installations Denominator: Total number of households NOTE 3 – SDG indicator 6.4.1* may be "Percentage change in water use efficiency over time".	6.4
T2.2 Water and sanitation	A2.2.2 Drainage system management	Percentage of drainage system ICT monitored.	%	NOTE 1 – Water quantity observation stations are used as a reference for evaluating an index representing the density of the natural and artificial drainage system monitoring network. Each observation node is associated to a drainage area either for natural drainage (rivers, lakes) and for	6.5 6.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				artificial systems (sewers, urban storm drains …). NOTE 2 – Calculate as : Numerator: The sum of the total drainage areas that are covered by the monitoring nodes Denominator: The total drainage area of the river basin closed to the outlet (lake or ocean). NOTE 4 – SDG indicator 6.5.1* may be "Degree of integrated water resources management implementation (0-100)".	
T2.2 Water and sanitation	A2.2.3 ICT Drainage system monitoring	Percentage of ICT-monitored drainage system	%	NOTE 1 – Calculate as Numerator: Length of drainage system monitored by ICT. Denominator: Length of drainage system.	
T2.3 Noise	A2.3.1 ICT Noise monitoring	Number of outdoor installations with applied ICT based noise monitoring per km^2	No. /km^2	NOTE 1 – ICT based systems refer to noise monitoring systems with sensors, which transmits measurements to a database where daily alerts and information are available and yearly summaries for each monitoring stations are computed. NOTE 2 – Calculate as: Numerator: Total number of outdoor installations of ICT based monitoring system. Denominator: Total city surface area.	
T2.4 Environmental quality	A2.4.1 Recycling of solid waste	Proportion of solid waste recycled compared to total collected solid waste.	%	NOTE 1 – SDG indicator 12.4.2* may be "Treatment of waste, generation of hazardous waste, hazardous waste management, by type of	12.4 1.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				treatment".	
T2.5 Biodiversity	A2.5.1 Protected natural area	Percentage of city area under environmental protection.	%	NOTE 1 – Calculate as: Numerator: Area of protected areas (hectares) reserved by law or other effective means. Denominator: Total city area (hectares).	11.4
T2.6 Energy	A2.6.1 Energy saving in households	Percentage of households with energy saving installations.	%	NOTE 1 – Calculate as: Numerator: Number of households with energy saving installations. Denominator: Total number of households.	7.3
T2.6 Energy	A2.6.2 Public buildings energy consumption	Annual energy consumption of public buildings	kWh / m2 / year	NOTE 1 – Calculate as: Numerator: Total electricity consumption by public buildings. Denominator: Total floor space. Calculate as kWh / m2 / year.	

I.3 Society and culture

There are 10 additional indicators in this area, covering: *e-learning, telemedicine, in-patient hospital beds, health insurance, disaster-related deaths and economic losses, disaster and emergency alert, Child Online Protection (COP), cultural heritage, and Gini coefficient*.

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T3.1 Education	A3.1.1	Percentage of city inhabitants using e-learning systems.	%	NOTE 1 – SDG indicator 4.3.1 is "Participation rate of youth and adults in formal and non-formal	4.3

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
	e-learning systems	.		education and training in the last 12 months".	
T3.2 Health	A3.2.1 Adoption of telemedicine	Percentage of patients involved in telemedicine programs	%	NOTE 1: Telemedicine programs include services, such as e-consultation, e-monitoring, online health care advice and guidance etc.	3.8
T3.2 Health	A3.2.2 In-patient hospital beds	Number of in-patient public hospital beds per 100 000 inhabitants	No / 100 000 Inhabitants	NOTE 1 – Calculate as: Numerator: Total number of in-patient hospital beds (public and private). Denominator: One 100,000th of the city's population. Express as hospital beds / 100,000 inhabitants.	
T3.2 Health	A3.2.3 Health insurance	Percentage of city inhabitants covered by health insurance.	%	NOTE 1 – The data may be collected from local statistics department, or may need to be extrapolated from national data.	3.8
T3.3 Safety – Disaster relief	A3.3.1 Natural disaster-related deaths	Natural disaster related deaths per 100 000 inhabitants.	No / 100 000 Inhabitants	NOTE 1 – Calculated as: Numerator: Number of annual natural disaster related deaths. Denominator: One 100,000th of the city's population. Expressed as the number deaths per 100,000 inhabitants. NOTE 2 – SDG indicator 1.5.1* and 13.1.1* may be "Number of deaths, missing people, injured relocated or evacuated due to disasters per 100'000 people".	1.5 11.5 13.1

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
T3.3 Safety – Disaster relief	A3.3.2 Disaster-related economic losses	Natural disaster related economic losses relative to gross domestic product	%	NOTE 1 – Calculate as: Numerator: Economic losses (last annual reporting period) related to disasters. Denominator : GDP of the city	11.5
T3.3 Safety – emergency	A3.3.3 Disaster and emergency alert	Percentage of disasters and emergencies with timely alerts.	%	NOTE 1 – Civil protection agencies are called to provide the list of events with the related alerting/risk level and also the quantifications of the misleading/worn alarms. NOTE 2 – Calculate as: Numerator: Number of disasters and emergencies with timely alerts. Denominator: Number of disasters and emergencies.	13.3 13.1 11.b
T3.3 Safety - ICT	A3.3.4 Child Online Protection (COP)	Existence of rules and regulations to ensure COP.	Checklist	NOTE1 – The city could work against cyber bullying by ensuring safety in online public services (for the use of ICTs in schools etc.). NOTE 2 – The verification contains examination in four aspects, including i) COP legislation; ii) COP regulations enforced in public service and facilities; iii) COP regulations properly enforced for web services; and iv) the coverage rate of qualified COP systems. This indicator is determined by the sum of the YES answers.	1.3
T3.5 Culture	A3.5.1 Protected cultural heritage sites	Percentage of city area related to protected cultural heritage sites.	%	NOTE 1 – Calculate as: Numerator: City area related to protected cultural heritage sites.	11.4

Topic	Indicator name	Description	Unit of Measure	Notes	Mapping to SDGs goals and targets
				Denominator: Total city surface area.	
T3.6 Social inclusion	A3.6.1 Gini coefficient	Income distribution in accordance with Gini coefficient.	No.		10.4

Appendix II
Complete list of core and additional indicators

(This appendix does not form an integral part of this Recommendation.)

The following table lists the core indicators in section 7 and additional ones in Appendix I.

Topic	No.	Indicator name	Core indicator	Additional indicator
T1.1 ICT infrastructure	C1.1.1	Internet access in households	x	
T1.1 ICT infrastructure	C1.1.2	household with a computer	x	
T1.1 ICT infrastructure	A1.1.1	Wireless broadband subscriptions		x
T1.1 ICT infrastructure	A1.1.2	Fixed broadband subscriptions		x
T1.1 ICT infrastructure	A1.1.3	Household with a mobile device		x
T1.2 Innovation	C1.2.1	R&D expenditure	x	
T1.2 Innovation	C1.2.2	Patents	x	
T1.2 Innovation	A1.2.1	SMEs		x
T1.3 Employment	C1.3.1	Employment Rate	x	
T1.3 Employment	A1.3.1	Creative industry employment		x

Topic	No.	Indicator name	Core indicator	Additional indicator
T1.3 Employment	A1.3.2	Tourism industry employment		x
T1.4 Trade – e-Commerce	A1.4.1	e-commerce purchase ratio		x
T1.4 Trade – e-Commerce	A1.4.2	Electronic and mobile payment		x
T1.4 Trade – Export/import	A1.4.3	Knowledge-intensive export/import		x
T1.5 Productivity	C1.5.1	Labour productivity	x	
T1.5 Productivity	A1.5.1	Companies providing online services		x
T1.6 Physical infrastructure – Water Supply	C1.6.1	Availability of smart water meters	x	
T1.6 Physical infrastructure – Water Supply	A1.6.1	Water supply loss		x
T1.6 Physical infrastructure – Water Supply	A1.6.2	Water supply ICT monitoring		x
T1.6 Physical infrastructure – Electricity	C1.6.2	Availability of smart electricity meters	x	
T1.6 Physical infrastructure – Electricity	C 1.6.3	Electricity system outage frequency	x	
T1.6 Physical infrastructure – Electricity	C 1.6.4	Electricity system outage time	x	
T1.6 Physical infrastructure – Electricity	A 1.6.3	Electricity supply management using ICT		x
T1.6 Physical infrastructure – Health infrastructure	A1.6.4	Sporting facilities		x

Topic	No.	Indicator name	Core indicator	Additional indicator
T1.6 Physical infrastructure – transport	C1.6.5	Public transport network	x	
T1.6 Physical infrastructure – transport	C1.6.6	Road traffic efficiency	x	
T1.6 Physical infrastructure – transport	C1.6.7	Real-time public transport information	x	
T1.6 Physical Infrastructure – transport	A1.6.5	Share of EVs		x
T1.6 Physical infrastructure – road infrastructure	A1.6.6	Traffic monitoring		x
T1.6 Physical infrastructure – transport	A 1.6.7	Pedestrian infrastructure		x
T1.6 Physical infrastructure – building	A1.6.8	Public building sustainability		x
T1.6 Physical infrastructure – urban planning and public space	A1.6.9	Urban development and spatial planning		x
T1.7 Public Sector	A1.7.1	Open data		x
T1.7 Public Sector	A1.7.2	e- Public Services adoption		x
T2.1 Air quality	C2.1.1	Air pollution	x	
T2.1 Air quality	A2.1.1	Air pollution monitoring system		x
T2.1 Air quality	C2.1.2	GHG emissions	x	
T2.2 Water and Sanitation	C2.2.1	Quality of drinking water	x	

Topic	No.	Indicator name	Core indicator	Additional indicator
T2.2 Water and Sanitation	A2.2.1	Water saving in households		x
T2.2 Water and Sanitation	C2.2.2	Access to improved water source	x	
T2.2 Water and Sanitation	C2.2.3	Water consumption	x	
T2.2 Water and Sanitation	A2.2.2	Drainage system management		x
T2.2 Water and Sanitation	A2.2.3	ICT Drainage system monitoring		x
T2.2 Water and Sanitation	C2.2.4	Wastewater treated	x	
T2.2 Water and Sanitation	C2.2.5	Wastewater collection	x	
T2.2 Water and Sanitation	C2.2.6	Household sanitation	x	
T2.3 Noise	C2.3.1	Exposure to noise	x	
T2.3 Noise	A2.3.1	ICT Noise monitoring		x
T2.4 Environmental quality	C2.4.1	Compliance with WHO endorsed exposure guidelines	x	
T2.4 Environmental quality	C2.4.2	Adoption of a consistent planning approval process with respect to EMF	x	
T2.4 Environmental quality	C2.4.3	Availability of EMF information	x	

Topic	No.	Indicator name	Core indicator	Additional indicator
T2.4 Environmental quality	C2.4.4	Solid waste collection	x	
T2.4 Environmental quality	C2.4.5	Solid waste treatment	x	
T2.4 Environmental quality	C2.4.6	Green areas and public spaces	x	
T2.4 Environmental quality	A2.4.1	Recycling of solid waste		x
T2.5 Biodiversity	C2.5.1	Native species monitoring	x	
T2.5 Biodiversity	A2.5.1	Protected natural area		x
T2.6 Energy	C2.6.1	Access to electricity	x	
T2.6 Energy	C2.6.2	Renewable energy consumption	x	
T2.6 Energy	C2.6.3	Electricity consumption	x	
T2.6 Energy	A2.6.1	Energy saving in households		x
T2.6 Energy	A2.6.2.	Public buildings energy consumption		x
T3.1 Education	C3.1.1	Students ICT access	x	
T3.1 Education	C3.1.2	Adult literacy	x	
T3.1 Education	C3.1.3	School enrollment	x	

Topic	No.	Indicator name	Core indicator	Additional indicator
T3.1 Education	C3.1.4	Higher education ratio	x	
T3.1 Education	A3.1.1	e-learning systems.		x
T3.2 Health	C3.2.1	Electronic health records	x	
T3.2 Health	C3.2.2	Sharing of medical resources	x	
T3.2 Health	C3.2.3	Life expectancy	x	
T3.2 Health	C3.2.4	Maternal mortality	x	
T3.2 Health	C3.2.5	Doctors	x	
T3.2 Health	A3.2.1	Adoption of telemedicine		x
T3.2 Health	A 3.2.1	In-patient hospital beds		x
T3.2 Health	A3.2.3	Health insurance		x
T3.3 Safety – Disaster relief	C3.3.1	Resilience plans	x	
T3.2 Safety – Disaster relief	A 3.3.1	Natural disaster-related deaths		x
T3.3 Safety – Disaster relief	A3.3.2	Disaster-related economic losses		x
T3.3 Safety – Disaster relief	A3.3.3	Disaster and emergency alert		x

Topic	No.	Indicator name	Core indicator	Additional indicator
T3.3 Safety – Emergency	C3.3.2	Emergency Service Response Times	x	
T3.3 Safety – ICT	A3.3.4	Child Online Protection (COP)		x
T3.3 Safety – ICT	C3.3.3	Information security and privacy protection	x	
T3.4 Housing	C3.4.1	Housing expenditure	x	
T3.4 Housing	C3.4.2	Informal settlements	x	
T3.5 Culture	C3.5.1	Connected libraries	x	
T3.5 Culture	C3.5.2	Cultural infrastructure	x	
T3.5 Culture	C3.5.3	Cultural resources online	x	
T3.5 Culture	A3.5.1	Protected cultural heritage sites		x
T3.6 Social inclusion	C3.6.1	Public participation	x	
T3.6 Social inclusion	C3.6.2	Gender income equity	x	
T3.6 Social inclusion	C3.6.3	Opportunities for people with special needs	x	
T3.6 Social inclusion	A3.6.1	Gini coefficient		x

Appendix III
KPI development in ITU-T

(This appendix does not form an integral part of this Recommendation.)

In February 2013, the ITU established the Focus Group on Smart sustainable Cities (FG-SSC) to assess the standardization requirements of cities aiming to boost their social, economic and environmental sustainability through the integration of information and communication technologies (ICTs) in their infrastructures and operations. While embarking on the SSC journey, it is important for cities to be able to understand and assess the stage of the transition they are at so that they may take the required steps to progress further. It is also important for urban stakeholders to be able to measure the performance of various smart sustainable city ventures once they are initiated. In this regard, the FG-SSC developed a set of international key performance indicators (KPIs) for cities aiming to become SSCs. The KPIs proposed by FG-SSC are in alignment with the definition of SSC and the framework provided by UN-Habitat in its City Prosperity Index.

The FG-SSC successfully completed its mandate in May 2015. The series of Technical Specifications and Reports on SSC KPIs are:

- Technical Specifications on overview of key performance indicators in smart sustainable cities, October 2014.
- Technical Specifications on KPIs related to the use of information and communication technology in smart sustainable cities, March 2015.
- Technical Specifications on key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities, March 2015.
- Technical Report on key performance indicators definitions for Smart Sustainable Cities, March 2015.

The starting point of the methodological approach to the United Nations Economic Commission for Europe (UNECE) Smart Cities Indicators is the Smart City PROFILES that the Environment Agency Austria (EAA) developed for twelve Austrian cities in 2013.

Since many Austrian cities and municipalities were actively pursuing energy-saving and climate strategies, setting examples which could help develop a joint knowledge basis and disseminate best practice models represented a good strategy to support cities in fulfilling this goal. In fact, by obtaining a better understanding of the key factors of urban development with respect to climate and energy issues, Profiles could provide important contributions, since they characterize cities in terms of different areas of activity in urban development. The Smart City PROFILES developed by the EAA were conceived to help Austrian cities and municipalities create smart and sustainable urban strategies and to implement them.

The EAA established a set of 21 indicators with the aim of developing city profiles for Austrian cities which gave a full picture of the characteristics and special features of cities and municipalities and could be reproduced by other cities. The indicators focused on climate change mitigation and energy efficiency in five areas of activity in urban development: buildings and settlement structures; transport and mobility; technical infrastructure; economy and population; and policy, administration and governance. From the analysis of the indicators' results, city profiles were drafted. They provided information about relevant sectors of urban activities, including business and economy, demography, strategic urban planning, governance, etc., and especially about the use of energy and resources as well as about the potential for increasing efficiency.

The resulting recommendations enabled cities to make better evaluations of their current status and their development, in particular with respect to energy and climate change mitigation, but also to other aspects influencing the quality of life of their citizens, and their competitiveness.

Due to the great diversity of the cities in the UNECE region, the Austrian Smart Cities PROFILES methodology, as well as the areas considered, was to be revised. Hence, a consortium of partners was established and the existing smart cities initiatives analysed.

In order to gather the most relevant indicators to evaluate smart and sustainable cities, the EAA scanned multiple initiatives whose output was the elaboration of indicators on sustainable urban development. They were analysed with regard to their relevance and practicability in low and middle income countries in the UNECE region. The key parameters of this assessment were:

- Name of publisher or organization who developed the indicator set
- Background information
- Addressed topics or indicators
- Data availability
- History of application (reference to cities)
- Sources of information, i.e. website, guidelines, and other literature.

In addition to these initiatives, other relevant sources have been analyzed such as: available statistical data at European and global level, i.e. EUROSTAT, Urban Audit, the World Bank, the WHO, the FAO, etc.; thematic maps on several issues, such as likelihood of drought, earthquakes, flooding, precipitations; other methods to assess the quality of urban features, such as perception surveys, checklists, expert judgments, etc.

From the above-mentioned assessment, ten (10) development fields divided into three (3) dimensions were identified. The three dimensions are: economy, environment, and society and culture. The development fields under the area “economy” are: economic development; and infrastructure and energy. The development fields under the area “environment” are: air, climate change and natural hazards; land and biodiversity; freshwater and oceans; and waste. The development fields under the area “society and culture” are: social issues; governance; health; education; and demography.

A preliminary set of top indicators for each development field was also defined. The preliminary set included 59 out of 456 indicators collected, and proposed 4 to 8 indicators per development field. For each indicator a description was provided according to the following parameters:

- Indicator title
- Source: the origin of the indicator
- Development field
- Sub-topic
- Literature: available guidelines and websites
- Relevance: only indicators with high relevance were chosen
- Feasibility (0 - 10): expert judgment with regard to feasibility
- Implementation: reference to regions where the indicator was already implemented
- Data availability: indication whether or not data is readily available; needs to be collected; is only available for certain regions, etc.

- Comments

The results of the study were summarized in the report “Smart Urban Solutions in the UNECE Region - Preliminary study on a flexible indicator set for smart cities”. [b-PST]

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